FOOD TECHNOLOGY

PUBLISHED BY THE INSTITUTE OF FOOD TECHNOLOGISTS

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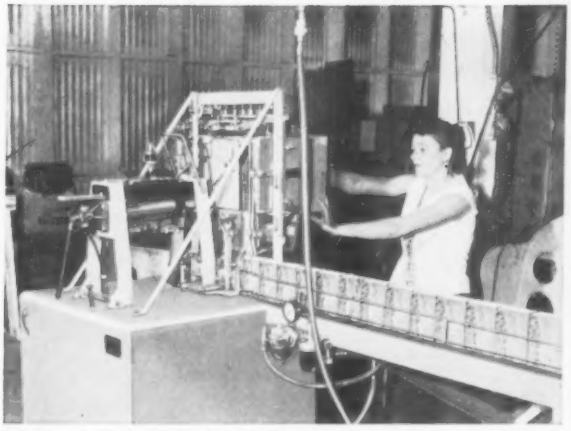

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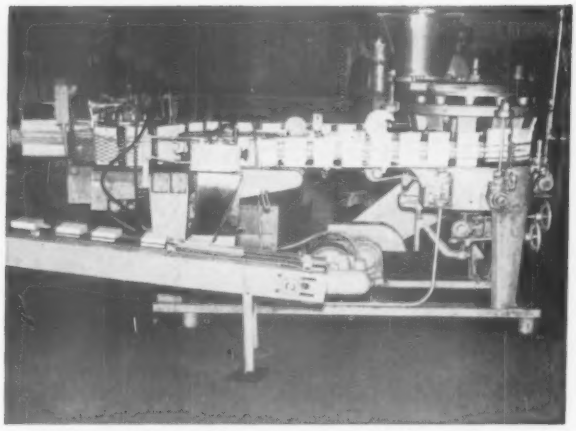

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FEATURING THIS MONTH . . .

FIFTIETH ANNIVERSARY SALUTE

As Lethbridge Experimental Farm Reaches Half Century Mark Food Technology Serves Future

C. Hamilton Kenney *
Information Service, Department of Agriculture, Ottawa, Canada

In August, the Canada Department of Agriculture's Experimental Farm at Lethbridge, Alberta, will have served agriculture 50 years. Half irrigable and half non-irrigable on dryland, the Experimental Farm over the past half century has been solving the problems peculiar to both irrigation and dryland farming. For example, through its breeding, variety testing and cultural experimentation with canning crops (to single out but one of many types), the Lethbridge Experimental Farm has been a source of definite information concerning the productive potential of the district. The modern Fruit, Vegetable and Sugar Beet Processing Laboratory built in 1950 has enabled the Experimental Farm to better serve the rapidly expanding vegetable canning industry and the long-established sugar beet industry.

THE LETHBRIDGE EXPERIMENTAL FARM was established in August, 1906, as a result of the problems created by the rapid influx of settlers into the newly-opened irrigable lands of southern Alberta, and the progress that extensive dryland wheat farming was making with the production of both spring and winter wheat. But it was not until 1943 that the idea of a fruit, vegetable and sugar beet processing laboratory for the Lethbridge Experimental Farm was born—and not until 1950 did it become a reality.

Aerial view, Experimental Farm, Lethbridge, Alta., Canada. Inset: Fruit, Vegetable and Sugar Beet Processing Laboratory. Farm was established in August, 1906, when this land was treeless prairie. Tree growth promoted by irrigation.

Charter IFT member, Dr. Malcolm B. Davis, who retired last year as Chief of the Horticulture Division, Experimental Farms Service, figured prominently in having the Processing Laboratory built, and was supported by delegations from the canning and sugar beet industries. Post-war conditions delayed construction of the laboratory until 1949. Completed the next year, George Strachan, an IFT member since 1946, was appointed Food Technologist in charge. Formerly, Mr. Strachan had been

(Continued on page 6)

The Lethbridge Experimental Farm to date has been served by three Superintendents: W. H. Fairfield, M.S., LL.D., O.B.E. (center), 1906-46, a graduate of the Agricultural Colleges of Colorado and Wyoming; A. E. Palmer, M.Sc. (left), 1946-53, graduate of Utah Agricultural College; and Herb Chester, B.S.A. (right), present Superintendent and a graduate of the University of British Columbia. In this picture, the three men have assembled in Rotation "U", a classic among experimental plots, and are discussing a good-looking sugar beet. Rotation "U", started in 1910, is considered today to be the oldest, continuous irrigation crop rotation in North America. It has demonstrated that the irrigated soils of southern Alberta can be maintained at a highly productive level by crop rotation and the use of barnyard manure and commercial fertilizer.

Today, the Experimental Farm's facilities are a far cry from the day the settlers came. Varied and intensive research activities are being conducted to investigate more critically the various phases of agriculture. The Experimental Farm and the adjacent Science Service Laboratories of the Canada Department of Agriculture provide southern Alberta — and the Prairies — with an important agricultural research center . . . which includes a modern Food Technology Laboratory built in 1950.

*Associate Editor, *Food Technology*.

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INSIDE SCIENCE

The Vital Story of Vitamin B_1

(Thiamine)

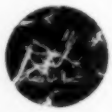
by Science Writer

History. The discovery of vitamin B_1 resulted from research into the cause of beriberi. Almost 50 years passed between Eijkman's discovery of the relationship of the disease to diet and the famous work of Jansen and Donath who first isolated the crystalline vitamin from rice bran.

Within ten years of that first isolation the vitamin's chemical structure was determined and it was successfully synthesized.

Eijkman's work resulted in the development of a theory that beriberi was caused by a lack of some factor in the diet and not by a toxin or infectious agent. This idea was not readily accepted until the growth of dietary knowledge proved it correct.

Isolation and Synthesis. In 1926 Profs. Jansen and Donath accomplished the isolation of crystalline vitamin B_1 from rice bran. In 1931 Windaus and co-workers successfully isolated pure vitamin B_1 and established its empirical formula. In 1936 R. R. Williams, and independently R. Grewe, explained the vitamin's chemical structure. That year, R. R. Williams and J. K. Cline accomplished the synthesis of thiamine which is in wide use today. Andersag and Westphal also synthesized the vitamin in 1936. Another synthesis was described by Bergel and Todd in 1937.



Photomicrograph of B_1 crystals

Chemical and Physical Properties. Thiamine hydrochloride is white, water soluble, with a nut-like, salty taste and yeast-like odor. Its empirical formula is: $C_{12}H_{17}ClN_4OS \cdot HCl$. Thiamine produced by synthesis is identical chemically and in biological activity with that obtained in pure form from nature.

Deficiencies. A deficiency of thiamine is characterized by these symptoms: depression, irritability, fearfulness, lack of initiative and interest, loss of appetite. Symptoms vary since in usual practice deficiencies of other water-soluble vitamins occur. Medical treatment is simple: a sufficient amount of thiamine is administered to relieve symptoms quickly and the physician provides for a continuing adequate intake.

Beriberi victim

A severe deficiency of thiamine leads to beriberi, a serious and sometimes fatal disease. While beriberi is almost a medical curiosity in the United States, it is common in countries in which polished white rice is a staple of the diet.

Human Nutrition Requirements. Thiamine is one of the nutritive elements the human body needs daily and does not store in quantity. The minimum daily requirements established by the U. S. Food and Drug Administration for the prevention of symptoms of thiamine deficiency disease are:

Adults	1.00 mg.	Children (1-5 incl.)	0.50 mg.
Infants	0.25 mg.	Children (6-11 incl.)	0.75 mg.

The Food and Nutrition Board of the National Research Council recommends the following dietary intake of thiamine for healthy persons in the U. S. A.

Recommended Daily Intake in Milligrams

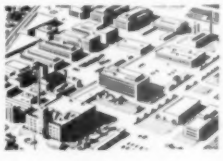
Age	*Men*	*Women*
25	1.6	1.2
45	1.5	1.1
65	1.3	1.0
Pregnant (3rd trimester)		1.5
Lactating		1.5

The Council recommendations for infants and children vary below and above these figures, based on age and sex. Various illnesses and stress situations can exhaust vital reserves of thiamine. So, for the physician, vitamin B_1 is prepared in various dosage forms and potencies for therapeutic and prophylatic use.

How do human beings receive thiamine? It is widely distributed in foods of animal and vegetable origin, particularly cereal grains and dry legumes. Because of public demand for refined products which millers must meet for obvious economic reasons, a loss of thiamine and other factors occurs during processing. The thiamine loss is overcome through the use of *enrichment* in cereal grain products for which Federal Standards exist, or in other foods such as breakfast cereals, by *fortification* or *restoration*. When enriching, fortifying or restoring, the food processor adds the necessary amount of pure thiamine (and other vitamins and minerals) to the food so that the finished product meets Federal, state and territorial requirements or contributes to the consumer an amount of the vitamin which dietary experts believe significantly useful.

Thiamine is extensively used for the enrichment of cereal grain foods such as white flour, white bread and rolls, macaroni products, farina, corn grits and meal, milled white rice. The story of these uses is delightfully told in a separate brochure which is available on request for reference or educational purposes.

Production. Huge production facilities at the Hoffmann-La Roche plant in Nutley, New Jersey, deliver highest quality thiamine *by the tons*. Roche manufactures thiamine hydrochloride and thiamine mononitrate. These fine products, which equal or exceed U.S.P. specifications, are ideal for use by pharmaceutical makers and food processors. Years of experience in research and manufacture have made Roche the leader in vitamins.



This article is published in the interests of pharmaceutical manufacturers, and of food processors who make their good foods better with essential, health-giving vitamin B_1. Reprints of this and others in the series are available on request. Write the Vitamin Division, Hoffmann-La Roche Inc., Nutley 10, New Jersey. In Canada: Hoffmann-La Roche Ltd., 286 St. Paul Street, West; Montreal, Quebec.

FOOD TECHNOLOGY

Published Monthly by the Institute of Food Technologists

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Subscription Rates: For members the cost of subscription is included in the annual dues. Non-members: domestic, $8.50 per year; Canada, Cuba and Mexico, $10.00 per year; all other foreign, $12.00 per year. Single and back copies: domestic, $1.50; foreign, $1.75.

Advertising Representatives: *Eastern:* Duncan Macpherson, 126 Summit Avenue, Jenkintown, Pa. *Midwestern:* Dale McCutcheon & Co., 154 E. Erie Street, Chicago 11, Illinois. *West Coast:* William A. Ayres Company, 233 Sansome Street, San Francisco 4, California.

Publication Office

The Garrard Press

119 West Park Avenue, Champaign, Illinois

Address to the Publication Office all requests for non-member subscriptions, back volumes, single copies (costs are listed above). Authors desiring reprints should address orders to this office; rates are printed on the order blank. (Requests for a single reprint of a published paper should be addressed to the author.)

FOOD TECHNOLOGY is published by the Institute of Food Technologists and printed by the Garrard Press, Champaign, Illinois, U. S. A.

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(Continued from page 2)

associated with F. E. Atkinson and C. C. Strachan, well-known IFT members with the Fruit and Vegetable Processing Laboratory on the Experimental Farm, Summerland, British Columbia. Readers will recall how the November, 1954, issue of *Food Technology* paid tribute to the achievements of the Summerland Laboratory on the occasion of its 25th anniversary that year.

VEGETABLE PROCESSING QUALITIES EVALUATED

The Lethbridge laboratory has devoted much time to evaluating the processing qualities of the various vegetable varieties grown in the district: peas, beans, corn, tomatoes, and others. Field tested by the Experimental Farm horticulturists, these varieties, if culturally adapted to the area, are checked by the Food Technologist for freezing and canning qualities. This project has assisted the industry as environmental conditions in the Lethbridge area are very critical.

MATURITY STUDIES

A thorough study into methods of measuring the optimum maturity for harvesting processing crops has been made. Food technologist, George Strachan, reports: "In this study it was found that physical tests such as the tenderometer and texturemeter gave excellent indications of the maturity of peas for canning and freezing." On the other hand, he states that most of the chemical tests were found to be unreliable as an index of maturity. Differences between the various varieties have been recorded. Mr. Strachan adds: "With the processors becoming increasingly 'quality conscious,' the importance of this work to the industry has been recognized and the study of beans, corn and other vegetables is being continued." In preliminary work on maturity studies of snap beans and sweet corn, physical and chemical analyses have been made on the major constituents. Seed-to-pod ratios appear to be the best index of bean maturity, while the succulometer appears to be the most satisfactory for corn. This physical test correlates well with such chemical tests as dry weight, alcohol-insoluble solids and sugar content.

DRY BEAN INVESTIGATIONS

The laboratory has carried out investigations to determine if dry beans grown in this area can be used for processing. Seven commonly grown varieties were tested for water imbibing properties, size ranges, ability to soften after soaking and their processing qualities. Water uptake was measured volumetrically while the degree of softening was determined with a needle-type penetrometer. These varieties show variations when soaked in distilled, tap and specially hardened waters for periods up to 48 hours. Pre-boiling one minute was found satisfactory to prevent pericarp sloughing when beans with below 12% moisture are to be used. Michelite, Ontario and Robust were preferred for commercial processing, but a Burbank strain that is slightly too large had the best flavor. The laboratory has achieved some success in reducing the pre-processing time required for the preparation of "beans with pork" (Canadian regulations do not permit the old-fashioned name of "pork and beans" on labels). With the food processing laboratory showing that several varieties can be processed into very acceptable products, farmers in these traditionally straight-wheat areas are becoming increasingly interested in growing beans as a specialized crop to diversify their operations.

NUTRITION SURVEY

A long-range project which will eventually lead to a compilation of nutritional values of the fruits and vegetables grown in southern Alberta has been undertaken by the laboratory. This survey entails a detailed chemical analysis; much has been completed, but average results over several years are needed to validate the data.

TOMATO PROCESSING STUDIES

The laboratory in conjunction with the horticulturists is studying the possibility of developing early tomato varieties suitable to the area and for processing. Already two promising early varieties have been developed and introduced—Earlinorth and Early Lethbridge. A thorough study has been made into their processing ability and qualities. "To assist the plant breeders," states Food Technologist Strachan, "the processing laboratory has undertaken a thorough examination of the tomato constituents that are affected genetically. These constituents include total acids, ascorbic acids, sugars, pectin and carotinoid pigments." He adds: "Already much interest has been shown by the processors in this endeavour as the tomato is an adjunct to many processed products."

Food Technologist George Strachan (right) discusses a canned sample of Early Lethbridge with Technician Sophia Tipman and Horticulturist I. L. Nonnecke. Lower left (l. to r.): Farthest North, Polar Circle, Earlinorth and Early Lethbridge explain latter's parentage. Processors are interested in the Laboratory's tomato processing studies.

COLOR EVALUATION

Color evaluation of several vegetable products has been carried out with the aid of a reflectance meter.

(Continued on page 8)

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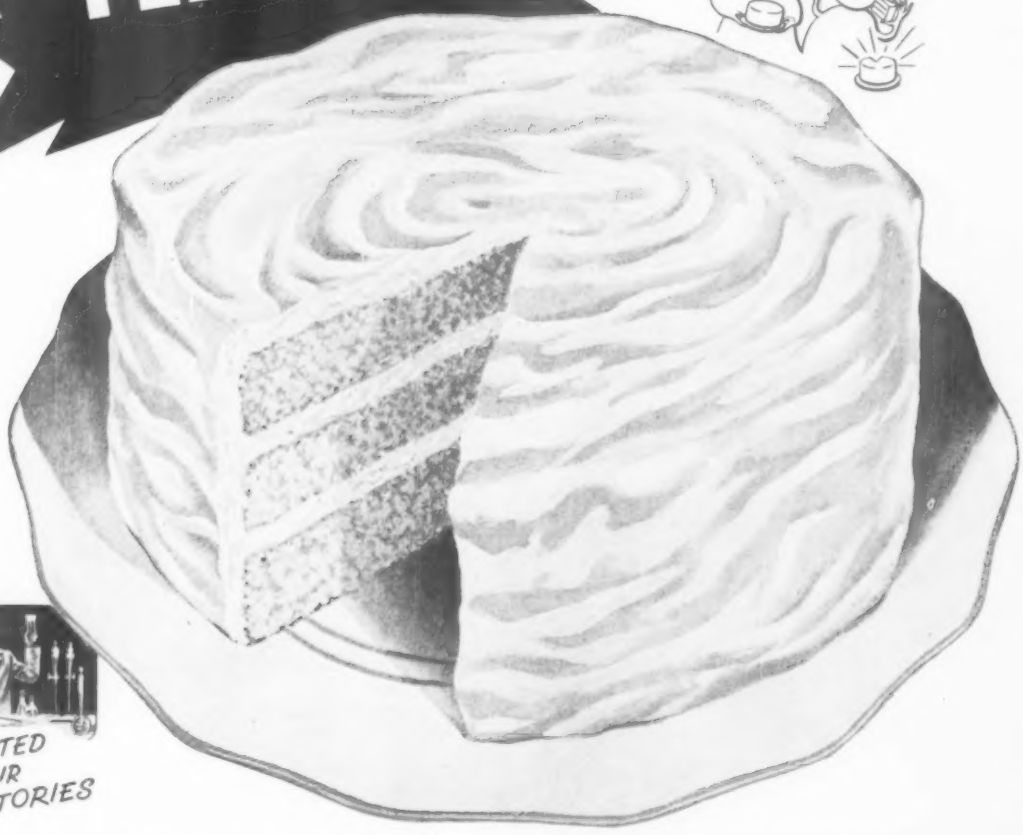

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(Continued from page 6)

Reflectance values of sweet corn were shown to correlate highly significantly with the carotinoid pigments, r = 0.83, while the regression of percent purity on carotinoids could be expressed as Y = 32.43 plus 0.0463X. Tomato skin color as measured with the Photovolt reflectance meter compared excellently with visually graded fruits. Areas of acceptability calculated from tristimulus values were worked out for various grades of tomato juice produced from instrumentally graded fruits.

OTHER STUDIES

Other studies have included the influence of water contaminants on processed foods; namely, peas, beans and corn. A preliminary report on an end-over-end rotary cooker has been made. In it, construction details of a laboratory model (capacity: 20 – 307 x 409 cans), including two illustrations, are given. When peas, snap beans and whole kernel corn were cooked at 206 deg. F. for 10 minutes, no appreciable quality differences were found. However, quality deteriorated when temperatures exceeded 270 deg. F., even when times were correspondingly reduced. End-over-end rotary cooked brine packed products are rapidly sterilized when high temperature short-time cooks are used.

LABORATORY WELL EQUIPPED

A 30- by 48-foot pilot plant has the necessary equipment for processing peas, beans, corn, tomatoes and other vegetables. The laboratory has its own steam plant. Freezing equipment includes a plate type freezer capable of producing temperatures to —50 deg. F., 640 cu. ft. of sub-zero storage space, and 3,000 cu. ft. of cold storage having a temperature range of 10 to 40 deg. F. Another laboratory with 450 sq. ft. of floor space is available on the second floor for chemical and physical examination of fruit and vegetable products. A test kitchen has also been provided for the preparation of taste panel samples.

A 30- by 48-foot pilot plant has the necessary equipment for processing peas, beans, corn, tomatoes and other vegetables; doors to freezing plant may be seen at far end.

CANNING INDUSTRY EXPANDING

The first canning factory in southern Alberta was started in 1934 at Taber, 30 miles east of Lethbridge, by R. Broder, founder of the Broder Canning Company. Peas, beans, and corn grown in rotation with sugar beets in the irrigated area surrounding the town were the vegetables processed. With the heavy demand for canned and dehydrated food during World War II, Mr. Broder built a second plant in Lethbridge. In 1945, a factory was opened at Brooks, a hundred miles to the northeast of Lethbridge, by the newly-formed Alberta Canning Company which the following year started another plant at Magrath, twenty miles south of Lethbridge. The same firm is building a new plant at Magrath, which is expected to be ready for the 1956 season, and also plans, it is reported, to quick-freeze 1½ million pounds of vegetables this year. In 1949, the original Broder plant at Taber was purchased by the Cornwall Canning Company who operated it until a new $500,000 plant was opened last September. The new plant handles 3½ times the 1949 output, it has been reported. In 1949, the canning season extended from July until October, whereas, today, the plant is able to

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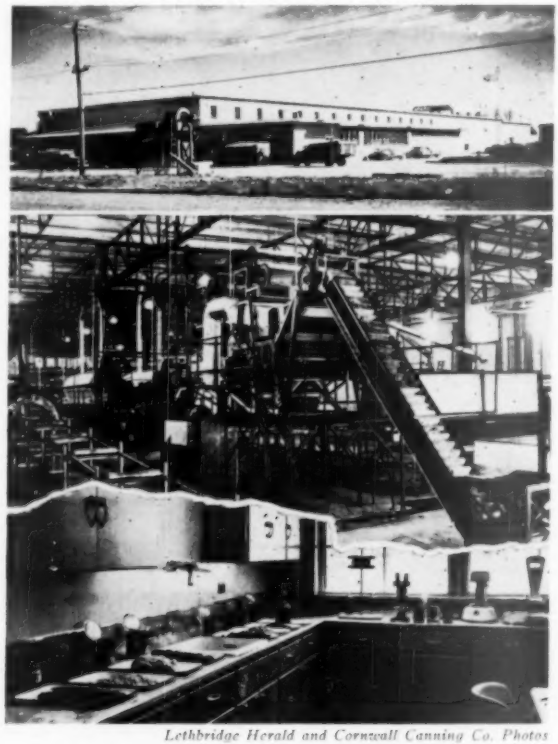

Lethbridge Herald and Cornwall Canning Co. Photos

The Lethbridge Experimental Farm has been a source of definite information for processors concerning the productive potential of the district. Top: New half-million-dollar canning plant of Cornwall Canning Company opened last year at Taber, Alberta, near Lethbridge. Middle: Modern equipment and laboratory (inset below) provide a food technologist's paradise for IFT member, R. Hyde, Cornwall's F. T.

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(Continued from page 8)

produce canned foods throughout almost the entire year. The same company, it is reported, also plans to build a vegetable quick-freezing plant at a cost of several hundred thousand dollars. It is expected to be ready for operation by the 1957 vegetable processing season.

The production of these plants has been expanding every year. To give an idea of the size and range of the canning industry which has developed in the area served by the Lethbridge Experimental Farm, the preliminary figures for the 1955 pack are revealing. Over 353,000 cases of peas were canned and 4,000,000 lb. quick-frozen; over 103,000 cases of green and waxed beans were canned and 278,000 lb. quick-frozen. Corn was lower at 417,000 cases while 526,000 lb. was quick-frozen. Other vegetables (beets, broccoli, cauliflower, carrots, asparagus) accounted for 100,000 cases, including beans with pork, and 169,000 lb. quick-frozen. Pickle cucumbers are also grown to supply the brining stations of Dyson's Limited and the Cornwall Canning Company at Taber. About 100 tons of sauerkraut is manufactured annually in the district.

SUGAR BEET INDUSTRY ALSO SERVED

The processing laboratory serves the sugar beet industry by making sugar and purity tests of beets and other work that may be required in sugar beet research which is an important part of the Experimental Farm's work. The first sugar factory was established in the area in 1905 but closed down after a few years of operation due to low yields resulting from low fertility and poor irrigation practice. The Experimental Farm, however, through proper rotation, fertilizing and irrigation treatment showed it was possible to get yields of around 20 tons to the acre with a sugar content of 17 to 18 percent. Average yields in 1928 were 7 tons and 12½ tons in 1950. Sugar processing was re-established in 1925, in recent years the industry modernized itself with three super refineries at Raymond, Picture Butte and Taber, and today produces 140 million pounds of sugar annually which, with its by-products, are valued at approximately $15 million.

CONCLUSION

The great variety of agricultural production found in the territory served by the Lethbridge Experimental Farm is reflected in a diversity of projects of which fruit, vegetables and sugar beet processing is but one. In no area of similar size in Western Canada is there such a complexity of soil and climatic conditions, varying from sub-humid in the foothills with black soil and lower temperatures, through the medium-rainfall areas of the Dark-Brown soil zone, to the dry Brown soil zone, and into submarginal lands too dry for grain farming. Superimposed on these varied natural conditions is the practice of irrigation, which introduces new possibilities in canning crop production. The processing laboratory, through sound food technology practice, has proved several "possibilities" which have been reflected in an expanding canning industry in southern Alberta. It is significant to note that as the Lethbridge Experimental Farm celebrates its Golden Anniversary the science of Food Technology is being applied in the search for better and adequate foods for mankind.

IFT REGIONAL SECTIONS . . .

SPEECHES, SPECIAL EVENTS, NEWS NOTES

FLEXIBLE FILMS FOR FOOD PACKAGING[a]

NELSON ALLEN
Sales Development and Technical Service
Film Department
E. I. du Pont de Nemours & Co.
Wilmington, Delaware

Over the past several years more and more foods have appeared in flexible film packages. This has been due to the rapid growth of the self-service method of selling foods and to the development of a variety of films for packaging.

Cellophane is the outstanding example. In its 30-year history it has grown to an annual production of about 350,000,000 pounds and over 75 percent of this is used for food packaging.

Along with cellophane, other films such as cellulose acetate, "Pliofilm," "Saran Wrap," "Cryovac," polyethylene, vinyls and "Mylar" polyester film have entered the food field and are finding wide applications.

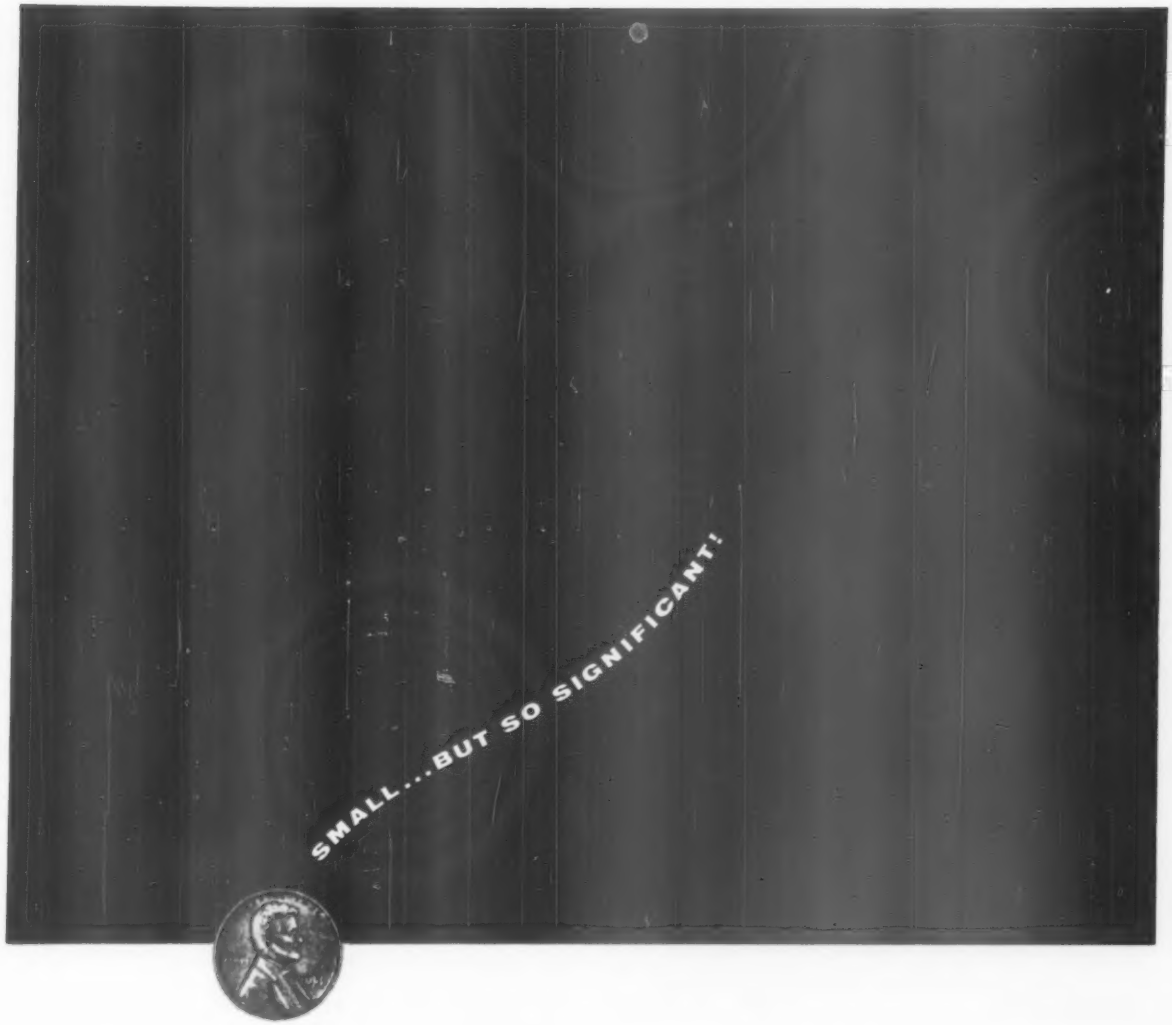
[a] A condensation of a talk given at the Regional Meeting of the Philadelphia and Maryland Sections of the Institute of Food Technologists, Wilmington, Delaware, November 11, 1955.

The extreme variety of foods poses a wide range of technical problems in packaging. The particular properties of a given film determine where it will be of most use.

Self-service merchandising of baked goods using various types of flexible film.

A consideration of a few typical foods will show the problems to be solved and how a film can best be applied.

(Continued on page 12)



A penny is small, yet, very often, it can be a big factor in the success of a business. Many businessmen, in the process of trying to save a penny or two, here and there, sometimes end up by losing dollars. The trick is to save without sacrifice. And so it goes in food processing.

Many processors use top grade ingredients and the latest techniques—yet, when it comes to spices—the small but significant ingredient that gives the product its taste, its sales appeal—many do their skill an injustice. After all this care, they cut corners when it comes to spices.

Knickerbocker spices...cinnamon, mace, nutmeg, paprika, ginger...are selected *for* manufacturers. They make the difference between a product that is just "O.K."—and one which will bring increased sales. From its raw state to its final form, each variety is kept uniform in quality...consistent in strength and flavor. And because Knickerbocker spices are *real* spices...there's less loss of flavor...you'll find they are stronger...more aromatic...*you'll use less!*

Not only will your customers *taste* the difference—your cash register will *show* the difference. Price lists and detailed information are available on request.

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KNICKERBOCKER
SPICES
Since 1842 America's Leading Importers of Fine Spices

Why throw emulsifier away?

If the shortening manufacturer dares not add his emulsifier *after* the deodorization step, he must figure on losing part of it in the deodorizer.

The way to avoid this is to use the unique *Myverol*® *Distilled Monoglycerides*. With this particular emulsifier there is no worry about odor, taste, or stability. Molecular distillation takes care of that. So there is no need to make up for what will wind up in the deodorizer condensers.

Deodorizer savings are only part of it. There are even bigger reasons why the concentrated mono of *Myverol Distilled Monoglycerides* goes a great deal farther than do the common mono-diglyceride mixtures. The only

real way to know how much less *Myverol* it takes to do a given job is to send for a sample and do some comparison testing. Not only is there money to be saved, but better quality commercial and household shortening to be turned out—better quality due in part to more uniform mono content.

For that sample, write ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York, Chicago, and Memphis • W. M. Gillies and Company, Los Angeles, Portland, and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

distillers of monoglycerides made from natural fats and oils

Also . . . vitamin A in bulk for foods and pharmaceuticals

DPi

Distillation Products Industries
is a division of **Eastman Kodak Company**

(Continued from page 10)

One of the largest users of films is the baking industry. Bread, cake, sweet doughs, doughnuts, and pies demand packaging, and self-service customers want to see what they buy. Cakes need a high degree of moisture protection but doughnuts and pies will become soggy if some moisture is not allowed to escape from the package. Films of varying degrees of water vapor permeability have been perfected for the appropriate foods. Films are used as direct wraps on high speed wrapping machines, as bags, and in window cartons. Cellophane, "Pliofilm," "Saran Wrap," polyethylene, and cellulose acetate are all used.

Meat has been a relatively recent convert to packaging for selling by self-service. Fresh meat must be protected from drying out but must have sufficient

Prepackaged fresh meats in transparent flexible films.

oxygen to maintain the desirable red color. This is especially important for fresh beef. Films of adequate oxygen permeability include special types of cellophane, polyethylene, and "Pliofilm."

On the other hand, smoked and cured meats fade in color on exposure to air and light. Highly moistureproof films may accelerate development of slime and molds when oxygen is present. Less moistureproof films may be used for some meats. Vacuum packaging and inert gas packaging of smoked and cured meats is growing rapidly. "Saran Wrap," "Mylar" polyester film, combinations of polyethylene with cellophane and with "Mylar" are proving themselves here.

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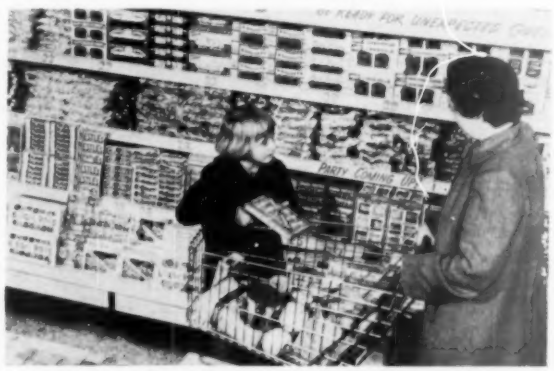

Various films and types of packages for candy.

For good health, the American people must ingest at least 60 tons of vitamin A per year. Over 10% of this they get from margarine.

Shortly after margarine fortification began in the 1930's, when the vitamin was commercially available only from fish liver oils, DPi began its vitamin A service to the industry, continuing smoothly into the present era of Myvax Vitamin A Palmitate and Acetate. For quotations and technical data on these superior synthesized products in cans of Myvapack Vitamin A adjusted to individual batch requirements, write *Distillation Products Industries*, Rochester 3, N. Y. Sales offices: New York, Chicago, and Memphis • W. M. Gillies and Company, Los Angeles, Portland, and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

"Myvax" and "Myvapack" are trademarks

leaders in research and production of vitamin A

DPi

Also . . . vitamin E . . . distilled monoglycerides . . . some 3500 Eastman Organic Chemicals for science and industry

Distillation Products Industries *is a division of* **Eastman Kodak Company**

(Continued from page 12)

Candy runs the gamut of needs from no moisture protection at all to protection in the highest degree. Highly durable films are needed for bags for hard candies. Protection for long periods of time must be provided to level out production schedules.

Crackers and biscuits may need protection from drying out or from taking up moisture. Again, long-time protection must be provided. Durability of packaging films on dry, crisp items for long storage at low temperatures may be a big problem.

A display of crackers using flexible film wrapping materials.

Like meat, fresh produce is just starting into packaging. Fruits and vegetables are living material and packaging must provide oxygen. Molding and rotting may be speeded up if too moistureproof films are used. The excellent durability of polyethylene has gained this material tremendous acceptance in packaging apples, potatoes and citrus fruits.

Fresh fruits and vegetables prepackaged for self-service.

Frozen foods of all types are packaged in flexible films. Obviously, excellent durability is a must. Low oxygen permeability is desired. The current trend to frozen prepared foods is making more demands on films. Polyethylene and its combinations with other films, "Pliofilm," "Saran Wrap," and "Cryovac" are used. Heating in the package for serving has become possible with the introduction of "Mylar" polyester film.

The development of high speed equipment for handling flexible films has contributed to the growth of the food industry. Direct wrapping, overwrapping, and bag making machines operate efficiently and rapidly. Many types of machines will take rolls of film, make bags, fill and seal them in one operation.

A new line of pre-cooked frozen meat dishes that can be heated in a plastic bag made with "Mylar" polyester film has been announced by Lüchow's Restaurant of New York. These specialties include Swedish Maet Balls with herb cream sauce, Salisbury Steak with mushroom sauce, and Beef Goulash with noodles.

Printing techniques on flexible films have been brought to a high state of perfection. Almost 50 percent of all the cellophane made is printed, made into bags or otherwise converted by manufacturers before going to the end user.

As new plastic materials are developed we can expect to see even more flexible films on foods. "Mylar" polyester film is a case in point. Originally it was used only in industrial applications and is only now beginning to get into the packaging field. Its great strength, inertness and stability at extremes of temperature will certainly find use on foods.

Proper packaging of foods requires a thorough knowledge of the properties of the foods themselves. In addition the chemical, physical, and mechanical handling properties of the packaging materials must be known. Only with this knowledge can the food be delivered to the consumer in the condition that the food processor intended. In self-service the package not only must protect, it also must sell. Flexible films, and especially transparent, flexible films can protect and sell.

NEW YORK . . . .

ADDITIVES CAN IMPROVE THE FOOD SUPPLY, HERE AND ABROAD

Nutritive food additives—their current status and future role in improving man's food supply—was the timely theme of Dr. C. G. King's talk at the March 21 meeting of the New York Section of the Institute of Food Technologists. Dr. King is Scientific Director, Nutrition Foundation, Inc., New York City.

Vitamin and mineral enrichment of cereal and dairy products is well established in this country, and its benefits are undisputed. Yet fluoridation of drinking

(Continued on page 16)

perfect flavor balance

in every RITTER tru-fruit wonex

Q. What makes every Ritter Wonex flavor so true-fruit perfect?

A. Just the right combination of fruit and other natural extractives—no synthetics are ever added. Result: perfect flavor balance, perfectly natural flavor in every Ritter Wonex!

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(Continued from page 14)

water, proposed after exhaustive scientific evidence of its complete safety, has met with considerable resistance in some quarters.

Predicting the ultimate use of fluoridized salt as a means of getting fluoride into the diet, the speaker called for careful study to avoid overdoses.

There is interest, too, in the addition of amino acids to cereal products. Their cost, however, is high compared to most commonly used additives, and they are needed most where the economy can least afford them.

This situation is most critical in the technically underdeveloped countries where the greatest nutritional problem is lack of high-quality protein. Here, food additives that can make native diets nutritionally adequate are important to economic recovery and political stability.

CHICAGO . . . .

Speaker at the May meeting of the Section, held at the Palmer House, was Mr. James M. Gillett, Assistant to the President, Victor Chemical Works. Mr. Gillett, a chemical engineer (University of Wisconsin, 1922) was an officer in the Ordnance Corps during World War I and following military service was engaged in engineering research for the Goodyear Tire and Rubber Company, later (1923) joining the Victor Chemical Works. He has been, successively, Chief of the Special Products Division, Director of Industrial Research, and Assistant to the President, his present position at Victor.

Mr. Gillett spoke to the Section on the very live topic, "Chemical Additives Legislation," and brought us up to date on current activities in this fast moving field. The material was presented in an objective manner and was well received by those in attendance.

Other items of interest are as follows: requests for tickets for the Southern California-Wisconsin football game in October are piling up, 42 to date to be exact. C. K. Wiesman, who succeeded to the chairmanship of the Section on the departure of W. J. Mutschler, former chairman, has appointed C. F. Evers to the post of Program Chairman for the Section and also to that of Regional Section Councilor to serve out W. J. Mutschler's unexpired term.

GREAT LAKES . . . .

Friday, April 20, 1956, was "Canada Day" for the Great Lakes Section with the Spring Meeting being held in the Prince Edward Hotel, Windsor, Ont. The morning was devoted to a plant trip through the Hiram Walker & Sons distillery where extensive operations covering grain handling, fermentation, waste drying, bottling and packaging had much to interest the food technologist. The afternoon technical session was addressed by four specialists from the Canada Department of Agriculture, Ottawa, while Dr. C. A. Morrell, Director of the Food and Drug Directorate, Department of National Health and Welfare, Ottawa, spoke to the dinner meeting on "The Food and Drug Directorate—Guardian of Public Health."

The following papers were given at the afternoon technical session:

"What's New In Our Food Microbiology Studies?"—Dr. A. H. Jones,* Senior Bacteriologist, Department of Agriculture, Ottawa, Canada.

"A Food Technologist Looks At Canadian Canning Problems"—Dr. W. D. Powrie,* Senior Food Technologist, Fruit and Vegetable Processing, Department of Agriculture, Ottawa, Canada.

"How To Improve Sanitation in Flour Mills, Grain Storages and Various Food Manufacturing Establishments"—Dr. H. E. Gray, Head Stored Product Insect Unit, Department of Agriculture, Ottawa, Canada.

"What Our Experimental Milling and Baking Tests Have Revealed"—Mr. A. G. O. Whiteside, Cerealist, Cereal Crops Division, Department of Agriculture, Ottawa, Canada.

WESTERN NEW YORK . . . .

The Section held its Annual Spring Meeting on April 27 at the Hotel Powers in Rochester, N. Y. The morning was devoted to a plant tour of the Bausch & Lomb facilities, two tours being arranged to accommodate everyone. Following luncheon at the hotel, the afternoon program consisted of the following papers being presented:

"Iodophors — A New Development in Sanitation" — Dr. Nathan E. Lazarus, President, Lazarus Laboratories Division, West Disinfecting Company.

"Development of New Pesticides"—Dr. Sherman K. Reed, Assistant Director of Research, Niagara Chemical Division, Food Machinery and Chemical Corporation.

"Food Aerosols"—W. E. Graham, Division Manager of Research, Can Division, Crown Cork & Seal Co., Inc.

PHILADELPHIA . . . .

The monthly dinner meeting of April 10 was devoted to the celebration of the 50th Anniversary of the Federal Food and Drug Administration. In the first portion of the meeting, Mr. C. S. Brinton reviewed the activities as a chemist when he worked with Dr. Harvey Wiley's "Poison Squad" just prior to 1906. He presented some astonishing facts of the great amount of food adulteration that existed at the turn of the century.

Some of the activities of the F. D. A. were brought up to date by the following members of the Philadelphia District:

Robert C. Stanfill, Chief.

"Inspections and Investigations"—T. C. Maraviglia, Chief Inspector.

"Analytical Facilities"—Chas. A. Wood, Ph.D., Chief Chemist.

"Spectrophotometry"—F. A. Rotondaro, Ph.D., Chemist.

"Microanalysis"—a demonstration by Manion M. Jackson, Chemist and Microanalyst.

"F. D. A. Technical Divisions"—Norman Kramer, Ph.D., Bacteriologist.

* IFT Member.

(Continued on page 18)

Now...a fresher-than-ever

IMITATION COCONUT FLAVOR!

With true flavor fidelity, Givaudan's Imitation Coconut successfully captures the fresh, subtle character of coconut.

This Givaudan development can be your key to coconut-flavored products that exactly suit the public taste. Our Imitation Coconut withstands high baking temperatures... brings out the full custard richness and creamy goodness of the real coconut flavor... has excellent shelf-life properties in your powdered products.

The mellow undertones of Givaudan's Imitation Coconut provide the flavor-rich appeal of fresh coconut for the greater success of your baked goods, candies, puddings, and powdered mixes. We invite your inquiries for both our liquid and powdered imitation coconut flavors.

Givaudan Flavors Inc.

330 West 42nd Street, New York 36, N. Y.

(Continued from page 16)

At the business session, the following were elected to office for the 1956-57 year:

Chairman: E. C. Dryden
Vice-Chairman: John Grimmins
Secretary: Norman Kramer
Treasurer: Fred Jacobson
Councilor: Rene Pouchain
Alternate Councilor: Richard Foster
Executive Committee: R. Mullan, C. Darlington, G. D. Boyd, A. D. Bowers.

Of interest to all IFT members, this Section passed a resolution concerning the establishment of a standing Food Industry "Contact" or Liaison Committee for the consideration of various problems of mutual interest to our Federal food regulatory agencies and the Food Industry. It is proposed that an ad hoc committee be appointed by the IFT President to study and make recommendations on this resolution.

SOUTHERN CALIFORNIA . . . .

On April 18th the Southern California Section met at Rodger Young Auditorium in Los Angeles to hear a stimulating report on the "Radiation Treatment of Foods" by Dr. La Verne E. Clifcorn, national president of the IFT for 1955-6. Almost 100 members and guests were present at the dinner preceding the meeting. A number of door prizes, donated to the section by several concerns, were also distributed at the dinner.

Early in his talk, Dr. Clifcorn startled his audience by pointing out that it costs the Armed Services about $40.00 per serviceman per year for refrigeration and attendant handling of foodstuffs. In addition, we are now reaching a stage wherein the range of a warship will be limited by its foodstuffs rather than its fuel capacity. He reviewed the progress that has been made in the preservation of foods by irradiation both by itself and in combination with conventional means of preservation. While it does not appear that irradiation will supplant the conventional means of food preservation in the immediate future, he did give an optimistic appraisal of its application in several fields during the next few years.

Speaking as President of the Institute, he urged greater participation of the membership in the affairs of the Institute. He also emphasized the work that can be done by individual members among the public to increase the professional stature of Food Technologists and a better appreciation of the food industry as a whole.

PERSONNEL

EUGENE G. LAUGHERY has been elected president of The Coffee Brewing Institute, Inc., 551 Fifth Ave., New York 17, N. Y. He formerly occupied the post of general manager. The Institute is a non-profit corporation which was formed in 1953 by the Pan-American Coffee Bureau and the National Coffee Association, to improve beverage coffee through scientific studies and consumer education.

MR. W. J. MUTSCHLER has been promoted from his assignment as Assistant to the General Manager for Research and Development, Continental Can Company, Chicago, to the post of General Manager of the Cannery Equipment Service Department of Continental Can Co., New York City.

DR. H. E. ROBINSON, Director of Laboratories, Swift and Company, has been selected general chairman of the IFT annual meeting for 1958. The meeting will be held in Chicago.

MEMBERSHIP CERTIFICATES AVAILABLE

Engrossed membership certificates will be furnished without cost to members of the Institute who were elected to membership prior to August 1, 1955. The Council of the Institute has authorized the issuance of these certificates to all members in good standing who desire them. Members elected after August 1, 1955, have been receiving them. If you are eligible for a certificate, write to the Executive Secretary, 176 West Adams Street, Chicago 3, Illinois.

In Memoriam

Frederick H. Leonhardt, 83, dean of the American essential oil industry, Chairman of the Board of Fritzsche Brothers, Inc., New York, and its affiliate, Dodge & Olcott, Inc., died on April 10, 1956, at Douglaston, N. Y. Mr. Leonhardt had been associated with his firm for over 60 years. He was born near Leipzig, Germany. In his early twenties, following an apprenticeship in chemistry with a local drug house and later a leading chemical manufacturer, he came to the United States to join the latter's New York branch, Fritzsche, Schimmel & Co. As a practical chemist he was aware of the industry's need for chemical and physical standards for a proper evaluation of the hundreds of essential oils then being received in this country from regions throughout the world. Years later, as Vice President and then President of Fritzsche Brothers, Inc., he initiated and carried out a long range, world-wide program of on-the-spot surveys by which the industry gained the accurate scientific data it so needed.

Mr. Leonhardt's benefactions were numerous. The new Leonhardt Memorial Chapel of the Community Church of Douglaston stands today as a monument to his generosity. A Trustee of the Community Church, Mr. Leonhardt was also a member of Albion Lodge of the Masonic Order, the Chemists' Club, Past President of the Drug and Chemical Club, the New York Athletic Club, North Hempstead Country Club, the Douglaston Club, and the Village Bath Club of Manhasset.

Surviving Mr. Leonhardt are his widow, Anna H., a daughter, Mrs. Dorothea Cassullo, his son, Frederick H. Leonhardt, Jr., and four grandchildren.

COULD YOU USE ANOTHER CUSTOMER?

(Continued from page 16)

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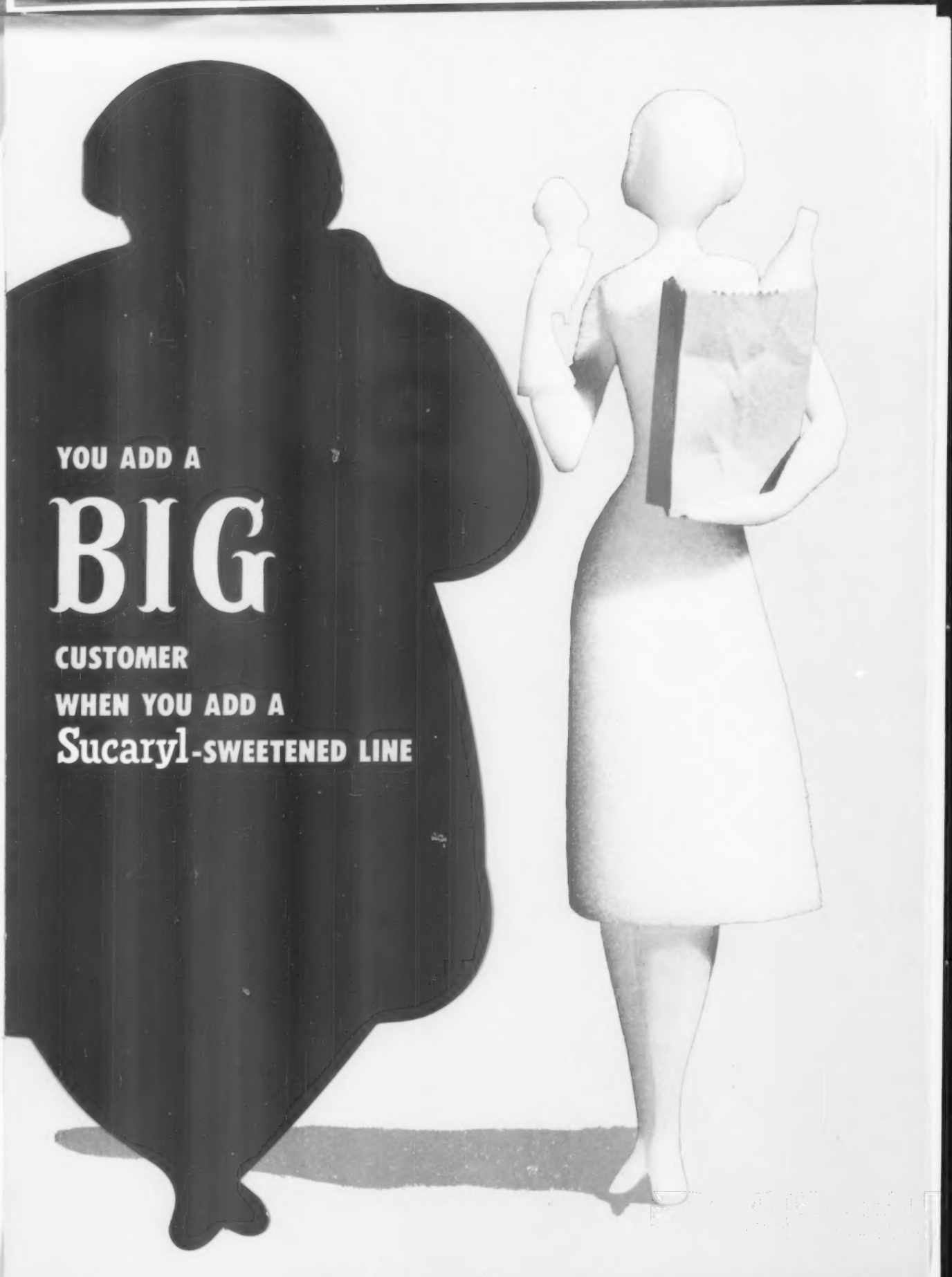
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BIG
CUSTOMER
WHEN YOU ADD A
Sucaryl-SWEETENED LINE

COULD YOU USE ANOTHER CUSTOMER?

SELECTED ABSTRACTS . . .

Compiled by H. A. Campbell

ANALYTICAL METHODS

Rapid estimation of dialdehyde content of periodate oxystarch through quantitative alkali consumption.

HOFREITER, B. T., ALEXANDER, B. H., AND WOLFF, I. A. [Northern Util. Res. Branch, (USDA), Peoria, Ill.]. *Anal. Chem., 27,* 1930 (1955).

A method, described here, is based on the discovery of reaction conditions under which a mole of alkali is consumed per mole of dialdehyde unit in oxystarch. There was good agreement between results obtained by this method and by other independent procedures over a wide range of dialdehyde contents. The simplicity of this method permits a single detn. to be made in 10 mins.

Determination of aldehydes using unsymmetrical dimethylhydrazine.

SIGGIA, S., AND STAHL, C. R. (Central Res. Lab., General Aniline & Film Corp., Easton, Pa.). *Anal. Chem., 27,* 1975 (1955).

An excess of hydrazine reagent is added to a sample, and, after the reaction is complete, the excess is titrated with standard acid. Ketones cannot be detd. by this method. Aromatic aldehydes can be detd. in the presence of ketones, but aliphatic aldehydes cannot. The hydrazine reagent is alk. and is stable toward decompn. and oxidation, making possible a precision and recovery within ± 1%. Because the method is nonaq. in nature, its range is extended beyond just H_2O-sol. samples. Acetals and carboxylic acids do not interfere.

Potentiometric determination of the base strengths of amines in nonprotolytic solvents.

HALL, H. K. (Pioneering Res. Div. E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware). *J. Phys. Chem., 60,* 63-70 (1956).

A reproducible titration method was devised and successful potentiometric titrations were performed on a large no. of monoamines and diamines in 5 solvents of varying nature: ethyl acetate, acetonitrile, nitrobenzene, nitromethane and ethylene dichloride. The titrant acids were perchloric, *p*-toluenesulfonic and perfluorobutyric, all in dioxane soln. Methanesulfonic acid was used as a soln. in the given solvent. The mid-pt. of the titration curve was taken as a measure of the dissocn. constant of the amine.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Studies on enzymatic tenderization of meat. I. Basic technique and histological observations of enzymatic action.

WANG, H., AND MAYNARD, N. (Div. Histology, Am. Meat Inst. Foundation, Univ. Chicago, Ill.). *Food Research, 20,* 587-97 (1955).

Papain (Adolph's meat tenderizer) and Rhozyme (Rhom and Haas Co.) have similar effects on muscle tissue components. Rehydration of frozen dried tissues in aq. soln. of enzyme allowed structural alterations to be used as criteria for assaying the action of proteolytic enzymes on muscle tissues.

Enzyme models. III. Synthesis of some new oxindole derivatives.

ENDLER, A. S., AND BECKER, E. I. (Chem. Labs. of Polytechnic Inst. of Brooklyn). *J. Am. Chem. Soc., 77,* 6608-10 (1955).

3-Aminooxindole and its derivs. have been shown to be enzyme models (specifically, carboxylase models). An enzyme model is a simple org. compd. that will catalyze a reaction similar to the action of an enzyme. Due to their comparative simplicity, the compds. are easy to synthesize and are almost always more stable towards degradation than an enzyme. Hence, they are of potential use in food products. This paper deals with the prepn. of some new carboxylase models. A mechanism for the action of the enzyme model on PhCOCOOH (benzoyl formic acid) to produce PhCHO plus CO_2 is given.

Enzyme and tobacco aging.

Battelle Tech. Rev., 5 (1), 13 (1956).

In a study of flue cured and air-cured tobaccos enzyme activity was detected for an oxidase, catalase, protease, invertase, cellulase, tyrosinase and probably decarboxylase and peroxidase. In the air-cured, the only appreciable enzyme activity found, resulted from decarboxylases.

The digestion of proteins by enzymes in the presence of gelatin.

CASTANEDA-AGULLO, M. (Dept. Gen. Physiol., Natl. Polytechnic Inst., Mexico, D. F.). *J. Gen. Physiol., 39,* 361-7 (1956).

It was observed that the digestion of casein and gelatin by crude and cryst. trypsin proceeded at the same rate whether present in sep. solns. or in the same soln. It was pointed out that this fact could not be explained if it is supposed that an intermediate enzyme-substrate compd. is formed according to addn. compd. theory, unless it be assumed either that there are two enzymes or two different active groups, which amts. to practically the same thing.

Studies on the enzymatic synthesis of glutamine.

VARNER, J. E., AND WEBSTER, G. C. (Agr. Biochem. Dept., Ohio State Univ., Columbus 10). *Plant Physiol., 30,* 393-402 (1955).

An improved method for the prepn. of the enzyme catalyzing the synthesis of glutamine from glutamate and NH_3 is described. The equil. const. for the overall reaction is given.

Metabolism of glutamine.

MEISTER, A. (Lab. Biochem., Natl. Cancer Inst., Bethesda, Md.). *Physiol. Revs., 36,* 103-27 (1956).

A review of the enzymatic reactions of glutamine and their possible physiol. significance. 264 references.

The nutritional significance of some peptides.

MELLANDER, O. (Dept. Med. Biochem., Univ. of Gothenburg). *Voeding, 16,* 363-7 (1955); *Z. Lebensm. Untersuch. u. Forsch., 103,* 138 (1956).

The phosphorylated peptides of milk protein are stable to enzymatic attack and act as complexing agents for Ca and Fe. Resistance of human milk protein is greater than that of cow's milk and may account for its higher nutritive value.

The syntheses of sugars from smaller fragments. Part X. Synthesis of L-glucoheptulose.

JONES, J. K. N., AND KELLY, R. B. (Dept. Chem., Queen's Univ., Kingston, Ontario). *Can. J. Chem., 34,* 95-7 (1956).

L-Glucoheptulose was prepd. by the action of muscle aldolase on a mixt. of *L*-erythrose and hexose diphosphate.

The hydroxyproline content of animal tissues.

ARONSON, J. N., AND ELVEHJEM, C. A. (Dept. Biochem., Coll. Agr., Univ. Wis., Madison). *Food Research, 21,* 109-11 (1956).

The application of a colorimetric method to the detn. of OH-proline in various animal tissues is reported. Muscle tissues from 4 species (beef, veal, pork, lamb) were shown to contain approx. 0.9 g. of OH-proline per 16 g. of N. The relation of OH-proline to tissue collagen is discussed.

MICROBIOLOGY

Sorbic acid as a selective agent in cucumber fermentations. I. Effect of sorbic acid on microorganisms associated with cucumber fermentations.

COSTILOW, R. N., FERGUSON, W. E., AND RAY, S. (Dept. Microbiol., Michigan State Univ., East Lansing). *Appl. Microbiol., 3,* 341-5 (1955).

At pH 5 and below, sorbic acid effectively inhibited yeasts. Effective levels at pH 4.6 were, 0.04% in salt free medium, 0.02% in 4% salt broth, and 0.01% in 8% salt broth. Lactic acid bacteria tested were not affected by sorbic acid regardless of pH. No utilization of sorbic acid by any cultures tested was noted.

The effect of certain fungicides on the thermal death rate of spores of Bacillus coagulins var. thermoacidurans.

EL-BISI, H. M., ORDAL, Z. J., AND NELSON, A. I. (Dept. Food Technol. Univ. Ill., Urbana). *Food Research, 20,* 554-8 (1955).

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tomato juice at pH 4.2 caused a significant decrease in D value of the thermal death rate. These fungicides were also sporostatic at levels of 50, 5, and 0.5 p.p.m. in thermoacidurans agar plates.

The nature of the binding of penicillin by bacterial cells.

SCHEPARTZ, S. A., AND JOHNSON, M. J. (Dept. Biochem., Coll. Agr., Univ. Wis., Madison). *J. Bacteriol., 71,* 84-90 (1956).

Alkaline extn. of cells of *Micrococcus pyogenes* treated with S^{35} penicillin resulted in destruction of the penicillin-cell complex. On the basis of several types of chromatographic evidence, the degradation product was identified as penicilloic acid. The hypothesis was proposed that binding occurs by cleavage of the β-lactam ring of penicillin and combination of the carbonyl or the imino group of that ring with the binding component.

A differential microbiological assay for vitamin B_{12} and pseudovitamin B_{12}.

BERMAN, D., YACOWITZ, H., AND WEISER, H. H. (Depts. Poultry Sci. and Bacteriol., Ohio State Univ., Columbus). *Appl. Microbiol., 4,* 49-52 (1956).

A simple microbiological procedure is described for the detection of pseudovitamin B_{12} and other non-B_{12} activity in crude samples. The method employs a differential assay using *Lactobacillus leichmannii* 7830 and *Lactobacillus acidophilus* 832 as the test organisms. Using this method it appeared that lyophilized beef liver, lyophilized beef kidney, fresh chick liver, and fresh chick kidney contained only vitamin B_{12}. Fish solubles, rabbit feces and fresh chick droppings contained appreciable amts. of non-B_{12} activity. The differential assay procedure was quant. when mixts. of pure vitamin B_{12} and pseudovitamin B_{12} were assayed, but was probably not quant. for crude samples due to the presence of other vitamin B_{12} analogs.

Yeasts. I. Morphology.

DE BECZE, G. I. (Res. Labs., Schenley Distillers, Inc., Lawrenceburg, Ind.). *Appl. Microbiol., 4,* 1-12 (1956).

This article presents information on the ecology, morphology, genetics, taxonomy, technics of cultivation and observation, nutrition, biochemistry, metabolism, and practical utilization of yeasts.

NUTRITION

The quantitative amino acid requirements of young women. II. Valine.

LEVERTON, R. M., GRAM, M. R., BRODOVSKY, E., CHALOUPKA, M., MITCHELL, A., AND JOHNSON, N. (Div. Home Econs., Okla. A. & M. Coll., Stillwater). *J. Nutr., 58,* 83-93 (1956).

The valine requirement of 7 young women was studied by using a semipurified diet. All subjects were storing N on a daily intake of 650 mg. of valine. In a later study, 8 other subjects maintained N equil. on an intake of 650 mg. of valine when threonine, tryptophan, phenylalanine and leucine were also present in min. amts. The lowest daily intake of valine which maintained all of the subjects in the zone of N equil. was 650 mg.

(Continued on page 25)

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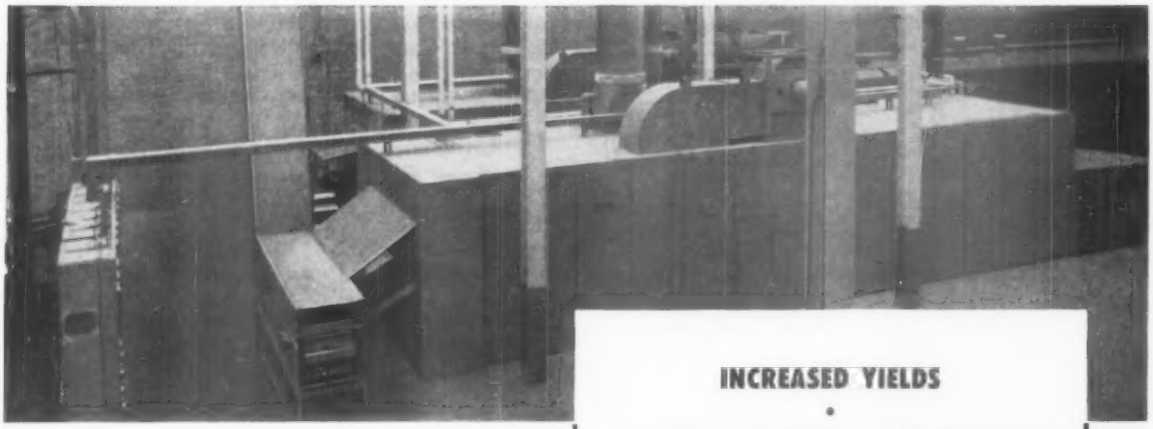

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ANNUAL MEETING ANNOUNCEMENTS . . .

ANNUAL MEETING IN ST. LOUIS DISTINGUISHED BY MANY OUTSTANDING EVENTS

Annual meetings of the Institute of Food Technologists have proved their importance repeatedly and are well established in the technical life of the nation. The ever-expanding influence of food research and development is clearly discernible in the Sixteenth Annual Meeting of IFT being staged in St. Louis. Gateway to the East and the West and centrally located with regard to the grain and livestock production areas of the nation, St. Louis is a fitting locale for this 16th anniversary of progress in the sciences and technologies that relate to food.

When the presidential gavel sounds the opening of the general session on June 11 in the Gold Room of the Sheraton-Jefferson, the manifold appraisals, points of view, advances in scientific theory, reports of new findings, and contributions to educational philosophy and practice that comprise the subject matter for this great council of food technologists will be released.

Within this comprehensive structure of formal and informal discussion of food science and its applications a number of events deserve special note.

President Clifcorn Completes Term

President L. E Clifcorn presents his address at the General Session, June 11. In a sense, the presidential address at an annual meeting of IFT is a valediction since the president's term of office closes with the close of the annual meeting. President Clifcorn has contributed energetically and competently to the advance of the Institute and to the professional progress of food technology during his term. He has travelled north, south, east, and west to meet with and speak before the IFT regional sections. Not only has he maintained close contact with the membership but also with the special purpose committees, the operating committees, his fellow officers at the national level, and with the IFT Council—an able president and a successful administration!

Also to be presented at the opening session are two addresses on topics of major concern to food technologists. C. N. Kimball of the Midwest Research Institute, Kansas City, will analyze the management view of research. In today's industrial world the problem is not the value of research, which is commonly accepted, but how to keep up with the concepts of creative research and reduce them to practice. Representative Miller, Fourth District, Nebraska, will present an expert evaluation of pending legislation on chemicals in food. Food preservation, dependent for centuries on techniques for preventing or delaying spoilage, has many resources today for the better achievement of preservation. Progress in the application of chemicals to foods, not only for preservation but also for the enhancement of flavor and texture qualities, has been rapid in this century.

Food and Drug Law Symposium

Of allied interest to the appraisal of legislation on chemicals in foods will be the symposium in commemoration of the 50th anniversary of the food and drug law—also an event of opening day. Moderator F. N. Peters will preside over discussions by George P. Larrick, Commissioner, United States Food and Drug Administration, Representative A. L. Miller, M. D., Nebraska, Eugene H. Holeman, Superintendent of Food and Drugs, State of Tennessee, Frank L. Gunderson, Consultant, Washington, D. C., and Henry A. Lepper, Past President, Association of Official Agricultural Chemists.

Circle These Events, Too

Also on Monday, opening day, Dr. Gail M. Dack, distinguished scientist and winner of the Babcock-Hart Award, will deliver his acceptance address, "Evaluation of Microbiological Standards for Foods." On Wednesday, June 13, Dr. B. E. Proctor, winner of another famous award, the Nicholas Appert Award, whose donor is the Chicago Section of IFT, will address the St. Louis convention of food technologists on the topic of "Food Horizons."

On the technical program are three sessions that have broad national interest—one entitled "Industry and Education," with Dr. W. A. Maclinn of Rutgers University presiding, the second a series of papers on food research on behalf of military feeding systems in an age of atomic warfare, Colonel J. D. Peterman, Commandant, Qm. Food and Container Institute for the Armed Forces, presiding, and a session on the radiation treatment of food—on which much attention has been concentrated in recent years. This project is still in the research stage but in some areas of the huge food preservation industry applications are now foreseeable. Other sessions will furnish, as usual, a full measure of technical data on problems of current food research concern as well as insight into their solutions.

NOTES ON SOCIAL EVENTS

Take Me Out to the Ball Game!

For the early birds who arrive in St. Louis on Sunday, June 10th, and have no other appointments, there will be the opportunity of seeing the St. Louis Cardinals play a double header on that afternoon.

After Dark

Evening entertainment includes the Sunday night "Mixer" in the Gold Room of the Sheraton-Jefferson

(Continued on page 30)

(Continued from page 22)

Calcium intake and rickets.

WALKER, A. R. P. *Nutrition Revs., 14,* 36-7 (1956).

A review of the possible relationship between a low level of Ca intake and the development of rickets in children. The author suggests it is wholly unwarranted to list prophylaxis against rickets as a reason for insisting on high Ca intakes.

Human pantothenic acid deficiency.

BEAN, W. B., HODGES, R. E., AND DAUM, K. *Nutrition Revs., 14,* 37-9 (1956).

A confirmation of clinical and metabolic observations noted in an earlier report. The neurologic clinical symptoms and signs of the pantothenic acid deficiency were particularly noteworthy.

Effect of a high fat fructose and casein diet on diabetic cataracts.

PATTERSON, J. W. (Dept. Anatomy, Med. Sch. Western Reserve Univ. Cleveland, Ohio). *Proc. Soc. Exptl. Biol. Med., 90,* 706-8 (1955).

A diet consisting of 50% fructose, 25% corn oil and 25% casein and fortified with vitamins and minerals was fed to diabetic rats with blood sugar levels over 350 mg. per 100 cc. of blood. On this diet the blood sugar was maintained at a high level, cataracts were prevented and growth rate accelerated. The beneficial effects of this diet suggest that cataracts and the failure in growth of diabetic rats are the result of a deficit of energy resulting from inadequate glucose utilization in the absence of insulin.

Experimental obesity. I. Production of obesity in rats by feeding high-fat diets.

MICKELSEN, O., TAKAHASHI, S., AND CRAIG, C. (Kirksville Coll. Osteopathy and Surgery, Mo.). *J. Nutr., 57,* 541-53 (1955).

Obesity was produced in normal male rats by the *ad libitum* feeding of a diet contg. 63% of fat and adequate amts. of vitamins, minerals and protein. When weanling rats were fed this diet, they gained wt. at a higher rate than rats on our "best" low-fat or stock diets. Three strains of rats have shown the same response. The max. wt. attained on the high-fat diet was 1655 g. Approximately 70% of the weanling rats of the Osborne-Mendel strain randomly secured from the stock colony have attained wts. over or close to 1000 g. when fed the high-fat diet. Obesity does not result from any genetic or hormonal disturbance.

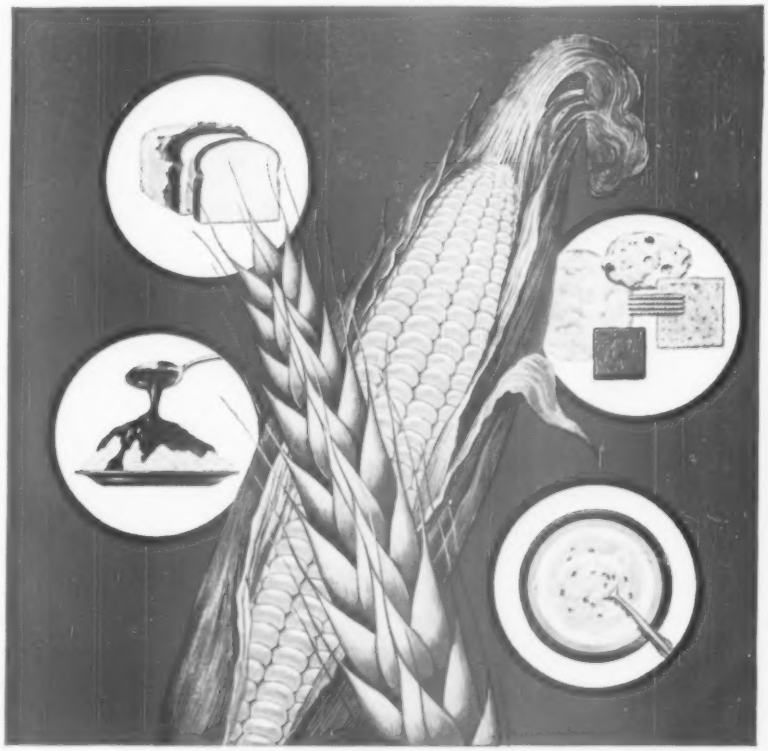
Effect of feeding diets exposed to ethylene oxide.

HAWK, E. A., AND MICKELSEN, O. *Nutrition Revs., 14,* 55-56 (1956).

Diets fumigated with ethylene oxide (sometimes used in food sterilization) and fed to rats indicate it caused extensive destruction of thiamine and other dietary factors.

Studies on comparative absorption and digestibility of acetoglycerides.

AMBROSE, A. M., AND ROBBINS, D. J. [Western Util. Res. Branch (USDA), Albany 10, Calif.]. *J. Nutr., 58,* 113-24 (1956).



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Results on the absorption and digestibility of acetoglycerides (acetostearin, acetooleln) justify the following conclusions. The acetooleins appear to be better absorbed than the acetostearins over a 4-hr. test period in rats. However, the acetostearins are absorbed at about the same rate as Crisco under the conditions of our exptl. procedures. The various acetoglycerides appear to be utilized by the rat in much the same way as natural fats. Data obtained on the digestibility of the acetoglycerides indicate that the acetostearins are not as readily digestible as the acetooleins. This, in all probability, is due to the large amt. of stearic acid formed during digestion, which combines with Ca to form Ca stearate which is not readily utilized. The digestibility of acetostearin is markedly improved when mixed with acetooleln, as indicated by a decrease in the amt. of fatty acid excreted as soap.

Recent progress in dietary research and dental caries.

PHILLIPS, P. H. (Coll. Agr., Univ. Wis., Madison). *J. Am. Dietet. Assoc., 32,* 110-14 (1956).

Recent studies show that oral clearance rate is a primary factor and saliva compn. may be of great importance in control of dental caries. Fermentable sugars are the principlal dietary contributor leading to dental caries, but are not the only dietary cause. Nutritive balance, especially of mineral elements, is essential to the dietary control of caries. It appears that certain anticariogenic factors may be present in foods.

Relationship of dietary protein and food intake to pyridoxine nutrition in the rat.

TULPULE, P. G., AND WILLIAMS, J. N. (Dept. Biochem., Univ. Wis., Madison). *J. Nutr., 57,* 529-39 (1955).

Regardless of the previous pyridoxine-deficient dietary regimen (simple pyridoxine deficiency, semi starvation, high protein regimen or nonprotein regimen), the rat is able to restore tissue pyridoxine concn. to normal when a complete 20% casein ration is fed *ad libitum.*

Multiple congenital abnormalities in the rat resulting from riboflavin deficiency induced by the antimetabolite galactoflavin.

NELSON, M. M., BAIRD, C. D. C., WRIGHT, H. V., AND EVANS, H. M. (Inst. Exptl. Biol., Univ. Calif., Berkeley). *J. Nutr., 58,* 125-34 (1956).

Little effect on fetal development was observed when stock female rats were given riboflavin deficient diets for the period of gestation. However, when the vitamin deficiency was accentuated by the addn. of the antimetabolite, galactoflavin, to the deficient diet for the entire gestation period or for only 4 to 6 days early in gestation, a high incidence of fetal death or congenital abnormalities resulted. The abnormalities observed included those of the skeleton, the cardiovascular and urogenital systems, the cerebrum and the eyes; herniations of the diaphragm and body walls were also observed. Skeletal defects predominated when the antimetabolite was given

(Continued on page 28)

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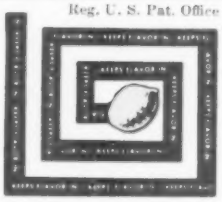

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Cloudy Lemon
Cloudy Lime
Cloudy Lemon-Lime

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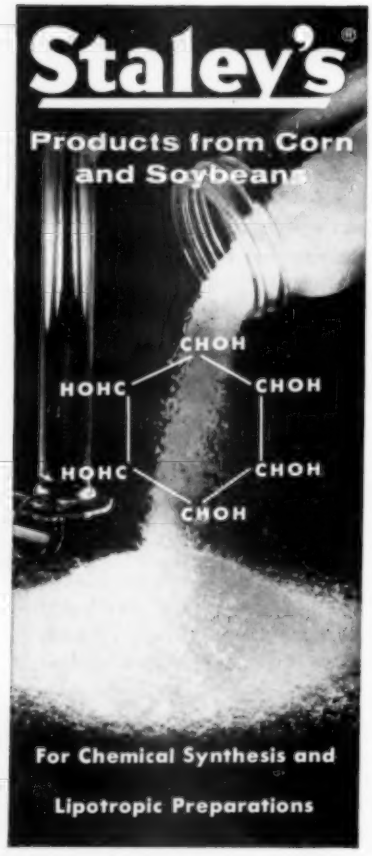

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(Continued from page 26)

throughout gestation. When diets contg. the highest level of the antimetabolite were supplemented with riboflavin throughout gestation, fetal development was normal.

Studies of reproduction in rats using large doses of vitamin B_{12} and highly purified soybean proteins.

RICHARDSON, L. R., AND BROCK, R. (Texas Agr. and Mech. Coll. System, Coll. Sta.). *J. Nutr., 58,* 135-45 (1956).

Two studies are described; one is the effect of large doses of vitamin B_{12} on the survival of young, and the other is the effect of different protein concentrates, including highly purified soybean protein, on reproduction. When vitamin B_{12} was added, the no. of young weaned ranged from 90 to 100% regardless of whether the amt. added was 10, 25, 500 or 1000 μg per kilo of diet. Five generations of females which received a synthetic diet that contained these purified soybean proteins weaned 90% or more of their young. These data show that the diet was not deficient in an unidentified factor or factors required for reproduction and lactation in rats, and it is concluded that if unidentified factors are required for reproduction in rats, they are held very tenaciously to the protein concns.

Effect of optical antipodes of 6-hydroxy norleucine (hexahomoserine) on growth and hematopoiesis in rats.

MERTZ, E. T., AND GOLUBOW, J. (Dept. Biochem., Univ. Pittsburgh). *J. Nutr., 58,* 51-7 (1956).

6-Hydroxy-DL-norleucine when fed at the highest level (1%), the D-isomer reduced the av. wt. gain to about one-fourth of that of the controls. At this same level, the L-isomer reduced the av. wt. gain to one-half of that of the controls. It is concluded that the D-isomer is a specific growth depressant, whereas the L-isomer depresses both growth and red blood cell production.

PHYSIOLOGY AND MEDICINE

The digestion and absorption of fat.

MATTSON, F. H. (Res. Div., Procter and Gamble Co., Cincinnati 31, Ohio). *Food Research, 21,* 34-41 (1956).

A review with 24 references. The probable route of hydrolysis of fat by pancreatic juice in agreement with exptl. data is hydrolysis of triglyceride to 1,2-diglyceride to 2-monoglyceride, with fatty acid being released at each step. The absorption mechanism is more obscure.

Growth and fat deposition in the mouse. A definition of obesity.

FENTON, P. F. (Dept. Biology, Brown Univ., Providence, Rhode Island). *Am. J. Physiol., 184,* 52-4 (1956).

The author advances the concept that true growth involves an increase in fat and in the fat-free component at a nearly const. ratio and that fat plotted against fat-free wt. yields a straight line with a slope near 0.1. Obesity is then defined as a marked positive deviation from this line.

Enzyme changes in fatty livers.

DIANZANI, M. U. *Nutrition Revs., 14,* 57-8 (1956).

A recent study of the distribution of pyridine nucleotides in both normal and fatty liver cells in the rat indicates that changes in the concn. of this factor occurs prior to the accumulation of fat in liver cells. This evidence supports the view of a close relationship between the pathogenesis of fatty infiltration and a decrease in pyridine nucleotides.

The effect of sitosterols on the serum cholesterol of man.

Nutrition Revs., 14, 39-41 (1956).

A review of the recent work of several investigators of the effects of sitosterols on the reduction of serum cholesterol of man. It was concluded that the eventual usefulness of beta sitosterol in controlling hypercholesterolemia cannot be predicted on basis of present evidence.

On the origin of cancer cells.

WARBURG, O. *Science, 123,* 309-14 (1956).

Cancer cells originate from normal body cells in two phases. The first phase is the irreversible injuring of respiration. In the second phase part of the injured cells perish from lack of energy, while another part succeed in replacing the irretrievably lost respiration energy by fermentation energy. Because of the morphological inferiority of fermentation energy, the highly differentiated body cells are converted by this into undifferentiated cells that grow wildly—the cancer.

Sweets and caries of the teeth.

CREMER, H. D. (Mainz, Ger.). *Fette u-Seifen, 57,* 915-19 (1955).

Extensive observations on humans and expts. on animals show that endangering of the teeth results not especially from sweets or sugars, but from carbohydrates in general. Exogenous and endogenous measures of preventing the danger are suggested.

ENGINEERING AND PLANT EQUIPMENT

Dispersed-phase holdup in packed countercurrent liquid-liquid extraction columns.

WICKS, C. E., AND BECKMANN, R. B. (Carnegie Inst. Tech., Pittsburgh, Pa.). *A.I.Ch.E. Journal, 1,* 426-33 (1955).

A study was made of the effect of flow rates, packing size and column diam. upon the holdings of the dispersed phase under reproducible packing conditions. An empirical equation is given for total holdup below the loading point.

The Hermetic centrifugal.

SULLIVAN, F. E. (De Laval Separator Co., Poughkeepsie, N. Y.). *Chem. Eng. Progress, 52,* 83-4 (1956).

The advantages of the Hermetic centrifuge in promoting more efficient sepn. in liquid systems contg. gummy materials are discussed.

Selection and application of evaporation equipment.

COSTON, M. M., AND LINDSEY, E. E. (Process Equip. Div., Rodney Hunt Ma-

(Continued on page 32)

IMITATION VANILLA BEAN FLAVOR BY FIRMENICH

Vanilla Bean Flavor by Firmenich stems from the vanilla bean. By original research, its components and desirable characteristics have been isolated, identified, and synthesized. By patient and painstaking laboratory techniques, they have been reconstructed for you in a precise and potent flavor material with all the aromatic qualities of the original.

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ANNUAL MEETING ANNOUNCEMENTS

(Continued from page 24)

Hotel where the Strolling Troubadours will be on hand to brighten the evening.

An evening at the world famous St. Louis Municipal Opera has been planned with a performance of "Annie Get Your Gun" as the attraction.

One evening has been set aside for a cruise by moonlight on the Mississippi. There will be dancing in air-conditioned comfort on the streamlined, luxurious "Admiral," with refreshments of your choice available at all times.

The Appert Award Banquet will be held on Tuesday evening in the Gold Room of the Sheraton-Jefferson Hotel at 7:00 P.M. There will be dinner music by a string ensemble, and entertainment by the Monsanto Men's Chorus.

Daytime—Program for the Ladies

A variety of activities and entertainment has been planned especially for the ladies. Included is a visit to the famous home of General Ulysses S. Grant, and a ride on a miniature railroad over 281 acres where deer, antelope, mountain goats and bison roam the area. The only Alaskan Seal Processing Operation in the United States may be seen at the Fouke Fur Company who will welcome the ladies to tour their plant.

Among the many luncheons scheduled for the ladies are: a buffet luncheon at Anheuser-Busch, luncheon in the beautiful St. Louis Art Museum in Forest Park, and a luncheon in the St. Louis Room of the Missouri Athletic Club.

Plant Tours

Thursday, June 14th, there will be many planned tours for members and their guests which will be of particular interest.

FOOD INDUSTRY TOPICS . . .

. . . by Norb Leinen

. . . in the public interest

Food Machinery and Chemical Foundation has become one of 16 organizations taking part in the National Merit Scholarship Program for sponsoring college scholarships. FMC will award four scholarships a year, at an estimated cost of $6,000 each, to male students interested in studying physics, chemistry, botany, entomology, biology, zoology, geology, mathematics, or engineering. Each scholarship is for four years at any accredited college of the student's choice. An educational grant to the college accompanies each scholarship. The FMC program will be administered by the National Merit Scholarship Corporation of Evanston, Ill., a non-profit organization that will screen and test applicants. Awards will be made on the basis of an annual nationwide talent search among secondary schools where qualified senior students will be given opportunity to take competitive examinations.

◆ ◆ ◆

Advertising is probably more guilty than sales and production for major faults in marketing logic, Mr. Walter Guild, president of Guild, Bascom & Bonfigli, Inc., San Francisco advertising agency, stated at the IFT meeting there on April 19. But he declared that all three important "legs of the marketing stool"—advertising, sales, and production—too frequently lack exact knowledge of consumer needs and demands. In food marketing, he said, many companies allow food brokers' or retailers' buyers to influence marketing policy. "The buyer may or may not be aware of the facts of life of marketing as a whole . . . [but] is he right from the consumer's standpoint? Who knows?" Mr. Guild asked. He called for "beautiful synchronization" of the various marketing functions. "Marketing today is so fiercely competitive that everything must be perfect. The time has passed when brilliant salesmanship will bail out a bad product. Or when fine advertising will compensate for a sloppy sales job," he concluded.

◆ ◆ ◆

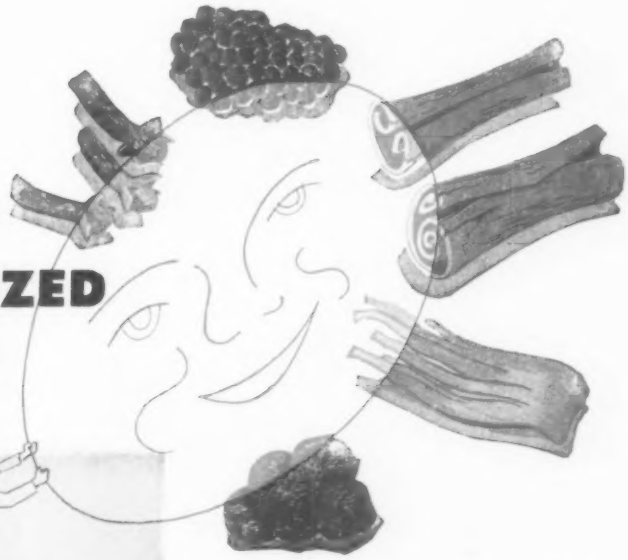
Addressing the New York Section of the American Association of Candy Technologists, Mr. Thomas C. Grenfell, assistant director of the analytical department, Chas. Pfizer & Co., Inc., termed quality control a cornerstone of the modern chemical industry, and one of the industry's most important responsibilities in serving the food, drug, and beverage producer. He detailed some of the strict safeguards employed by chemical firms in producing ingredients for industry. "From raw material to finished product," he said, "chemical ingredients are subject to hundreds of separate tests ranging from simple production-line inspections to complex spectrophotometric analyses." These relentless testing procedures, he added, assure the candy technologist that the ingredients he uses will measure up to, and surpass, the most rigid quality specification.

◆ ◆ ◆

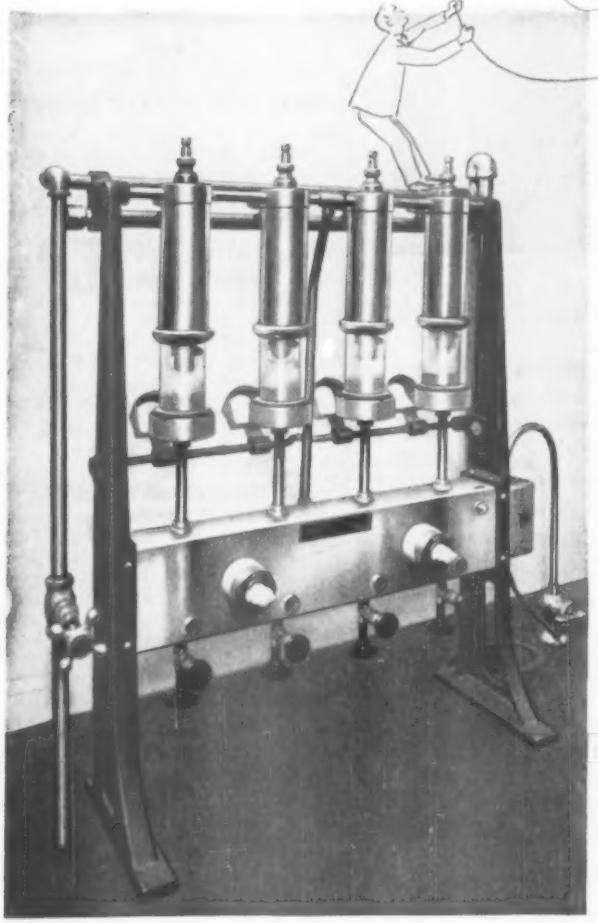
Existing government controls and other factors are sufficient to keep advertising claims within proper limits, Mr. Paul J. Cardinal, vice president in charge of the Vitamin Division, Hoffman-La Roche, argued vigorously in the March issue of the *Journal of the American Public Health Association*. Addressing a group among whom there have been severe critics of food advertising, Mr. Cardinal cited the effectiveness of the Federal Trade Commission, Food and Drug Administration, Post Office Department, and Better Business Bureau actions, and regulations arising from industry, in stopping false and misleading claims. "Apart from them," he maintains, "advertising is

(Continued on page 44 following technical papers)

How Griffith's Extraction Process* Assures Better-Flavored Products



®PEPPEROYAL AND SOLUBLIZED SEASONINGS



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for liquefaction and hydrolysis of starch to produce soluble dextrins and sugars—also, to remove starch causing filtration problems and turbidity.

GLUCOSE-OXIDASE
to prevent browning due to glucose or oxygen and to increase shelf-life of food and beverage products.

PROTEINASES
for the modification and hydrolysis of proteins in food manufacturing and pharmaceutical operations.

PECTIC ENZYMES
for the hydrolysis of pectins in fruit and fruit juices to speed processing and to make fruit juices sparkling clear for consumer appeal.

TAKAMINE

TAKAMINE LABORATORY
DIVISION OF MILES LABORATORIES, INC.
CLIFTON • NEW JERSEY

(Continued from page 28)

chine Co., Orange, Mass.). *Chem. Eng. Progress, 52,* 49-52 (1956).

The proper selection of evaporator types is considered with respect to liquid viscosity, heat sensitivity, number of effects, tolerable servicing cycle, corrosion, and possible plugging.

Cost factors in evaporator design.
KOHLINS, W. D., AND ENGLANDER, H. P. (Buflovak Equip. Div., Blaw-Knox Co., Buffalo, N. Y.). *Chem. Eng. Progess, 52,* 45-8 (1956).

Practical examples are given whereby costs can be reduced by proper evaporator design.

Apparatus for molecular filtration.
HISKEY, C. F., AND KIVERT, A. N. (International Biochem. Corp., Brooklyn 20, N. Y.). *Anal. Chem., 28,* 246 (1956).

A new type of mol. filter consists of a long tubular cellulosic membrane surrounded throughout its entire length by a flexible braid. This filter element is coiled and encased in a nylon bag. Closures are made at the entrant and the exit ends of the tube. The main advantage of this design is the high filtration rate, up to 500 ml./hr. at 100 lbs. pressure for the lab. sizes. It may be operated continuously.

FOOD AND FOOD TECHNOLOGY

BAKING AND BAKERY PRODUCTS

Sorbic acid as a fungistatic agent for foods. XI. Effectiveness of sorbic acid in protecting cakes.
MELNICK, D., VAHLTEICH, H. W., AND HACKETT, A. (Res. Labs., The Best Foods, Inc., and Drake Bakeries, Inc., Brooklyn, N. Y.). *Food Research, 21,* 133-45 (1956).

Sorbic acid is approx. four times as effective as propionate. This has been established both on lab. and com. scales. No alteration of cake flavor results from protective levels of sorbic acid. No measurable loss of sorbic acid occurs during cake manuf.

BEVERAGES

Enzyme protects canned drinks.
BARTON, R. R., RENNERT, S. S., AND UNDERKOFLER, L. A. (Res. Dept., Takamine Lab., Inc., Clifton, N. J.). *Food Eng., 27* (12), 79-80 (1955).

The shelf life of canned soft drinks is shown to be extended by glucose oxidase, which retards iron pickup, cuts color fading.

CEREALS AND GRAINS

The carbohydrates of the gramineae. VI. The nature of the water-soluble polysaccharides of the flour of wheat.
GILLES, K. A., AND SMITH, F. (General Mills Res. Lab. Minneapolis, Minn.). *Cereal Chem., 33,* 29-37 (1956).

Wheat gum was extd. from the flour of spring and winter wheat with H_2O and with aq. $(NH_4)_2SO_4$. While all samples of the gums contained arabinose, xylose, and glucose, those made by the $(NH_4)_2$

(Continued on page 34)

BUILDING BETTER "BODY" . . . . . for foods and drugs

For years, makers of candies, flavors, cough syrups, lozenges, lotions and other food, drug and cosmetic preparations have used Glycerine to provide humectant, demulcent or solvent action. Recent research with new thickening agents indicates that these properties of Glycerine will soon be extended to a whole new range of food and drug preparations.

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☐ Vol. 1: 1952, $9.75
☐ Vol. 2: 1954, $8.50
☐ Vol. 3: 1954, $6.75
☐ Combination price—all three volumes, $17.50

☐ **DRYING & DEHYDRATION OF FOODS,** *New 2nd Edition, by H. W. von Loesecke.* Covers newest advances in methods and equipment for dehydrating all types of fruits, vegetables, meats, fish and dairy products. Describes plant sanitation, waste disposal, nutritional values, packaging, storing and rehydration of dehydrated foods.
1955, $7.50

☐ **OUTLINES OF FOOD TECHNOLOGY,** *2nd Edition, by Harry W. von Loesecke.* Provides a basic picture of present-day food technology covering recent advances in handling raw materials, processing, equipment, machinery, packaging, preserving, storing and marketing all types of foods and food products. Includes such developments as the use of electronics, quick freezing techniques, etc.
1949, $8.50

☐ **HANDBOOK OF FOOD & AGRICULTURE** *edited by F. C. Blanck.* Over 1,000 pages of expert information on the newest applications of science to the food and agricultural fields! Covers: soils and plant growth; fertilizers; insecticides; growth regulants; essential nutrients; storage of raw products; food processing; preservation; packaging; quality control; waste disposal; and many other important topics.
1955, $12.50

☐ **INSTRUMENTS FOR MEASUREMENT AND CONTROL** *by Werner G. Holzbock.* Describes and illustrates all recent devices for measuring and controlling temperature, moisture, pressure, flow, uniformity, etc. Discusses the design, construction and operation and comparison factors to consider in choosing the proper instrument for a particular job.
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☐ **PACKAGING ENGINEERING** *by L. F. Narail.* First to describe all packaging materials, their best uses, and methods employed by packaging engineers to obtain the most efficient results at lowest possible cost. Covers types of containers, machinery, package design, protection against deterioration, labeling, testing, and all other engineering and design aspects.
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☐ **CHEMICAL PROCESS MACHINERY,** *2nd Edition, by E. R. Riegel.* Describes and illustrates latest developments in the equipment in the chemical and process industries. Includes such striking devices as multisphores and multicylinders, high-speed centrifugal separators, the P-A cyclonic spray tower, the P-A Venturi scrubber, continuous crystallizers, absorption refrigerators and the turbo-dryer.
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ACS Monograph, 1953, $9.50

☐ **PRINCIPLES OF EMULSION TECHNOLOGY** *by Paul Becher.* A concise explanation of the fundamentals of emulsion technology in terms of practical industrial problems. Discusses the chemistry involved in dispersions and emulsions, emulsifying agents, surface activity, and demulsification. Equipment is described and illustrated, and methods of testing emulsion properties are covered in detail.
1955, $2.95

☐ **VEGETABLE FATS AND OILS** *by E. W. Eckey.* Describes all of the most important vegetable fats and oils. Includes latest information on the plant from which each kind of fat is derived, the composition of the fat-bearing part, and the characteristics of the fat itself.
ACS Monograph, 1954, $16.50

☐ **MARINE PRODUCTS OF COMMERCE,** *2nd Edition, by Donald K. Tressler and James M. Lemon.* Deals in considerable detail with all articles of commerce derived from the sea ranging from magnesium and pearls to whale oil and fish meal. Emphasizes the equipment and gear required in many types of fisheries, and provides detailed tables of data on the yield of these fisheries.
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☐ **BYPRODUCTS FROM MILK** *by E. O. Whittier and B. H. Webb.* Describes in detail the physical and chemical characteristics of milk, skim milk, whey, buttermilk and their components, and tells how these materials are converted for use in both food and non-food products. Explains methods of making whey cheeses, bakery products, ice cream mix, candy, milk sugar, casein and other products.
1950, $6.00

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(Continued from page 32)

SO_4 method had the highest pentosan content. The gums probably consist of a mixt. of 2 polysaccharides, one composed of arabinose and xylose, and the other of glucose. The close assocn. of the 2 polysaccharides was revealed by the fact that their sepn. by fractional pptn. from aq. soln. with MeOH could not be accomplished.

Cooking qualities of rice being tested.
SMITH, G. T. *Rice J., 59,* 24-5, January 1956.

A regional rice quality testing lab. has been established in Beaumont, Texas. Rice cooking quality work will be coordinated with that of breeding programs, in an attempt to produce a "tailor-made" rice, to satisfy farmers, consumers, processors and the rice industry.

COFFEE

Finding the nutritional value of coffee.
LAUGHERY, E. (Coffee Brewing Inst., Inc.). *Tea & Coffee Trade J., 110,* 25-6, February 1956.

Review of progress made in research projects sponsored by Coffee Brewers Inst. with emphasis on the nutritive value of niacin available in coffee.

CONFECTIONS AND DESSERTS

The influence of ice milk and mellorine on ice cream volume.
DAHLBERG, A. C. (Dept. Dairy Ind., Cornell Univ., Ithaca, N. Y.). *Ice Cream Trade J., 52,* 64-6+, February 1956.

Percentage increases in the production of the milk sherbet and ice, and mellorine were much greater than for ice cream from 1948 to 1953. Ice milk production did not replace ice cream production and it increased total gallons of all ice cream like products. Similarly, gains in ice cream production were greatest in those states that showed the largest gain in production of sherbet and ice. On the other hand, mellorine replaced ice cream without obvious increased production in total gallons. Ingredient cost of ice milk and mellorine are about comparable. Ice milk contains two-thirds of the calories of ice cream.

FATS AND OILS

A simplified method of preparing pure mono-, di- and tri-glycerides.
HARTMAN, L. (Dept. Scientific and Industrial Research, Wellington, New Zealand). *Nature, 176,* 1024 (1955).

The direct selective esterification of glycerol without recourse to blocking is described. The method depends upon the use of N,N-dimethylformamide to obtain a homogeneous mixt. of glycerol, fatty acid chloride, and pyridine.

GELATIN AND GUMS

The constitution of plant gums.
SPRIESTERSBACH, D. R. (Univ. Minn.). *Dissertation Abstr., 15,* 2418 (1955).

The structures of the following were elucidated; chagual gum (an exudate of the species of *Puya*), the amide of an aldobiuronic acid compd. derived from mesquite gum, and degraded arabic acid.

The enzymic hydrolysis of carrageenin.
YAPHE, W., AND BAXTER, B. (Maritime Reg. Lab., Natl. Res. Council, Halifax, Nova Scotia, Canada). *Appl. Microbiol., 3,* 380-3 (1955).

A marine bacterium yielded an extracellular enzyme which hydrolyzes carrageenin. Optimum activity was found at 40° C. and pH 7.5. The enzyme did not hydrolyze agar or extracts from several agarophytes.

The effect of temperature and acidity on the dry storage of sodium carrageenate.
GORING, D. A. I. *Can. J. Technol., 34,* 39-41 (1956). Data showing the change in viscosity of Na carrageenate with pH and storage time were obtained.

POTATOES

The mechanism of growth of starch granules in the potato tuber, studied with carbon-14.
BADENHUIZEN, N. P., AND DUTTON, R. W. (Postgrad. Med. Sch., Ducane Rd., London). *Biochem. J., 62,* 13-14P (1956).

Potato plants were allowed to photosynthesize in an atm. contg. $C^{14}O_2$. Starch was then isolated from the tubers and the granules examd. by the stripping film technique. Observations resulting from the use of this technique led to the conclusion that growth takes place by apposition, and that it may be a very slow process which is entirely dependent on the supply of carbohydrate.

A histological study of the influence of sprout inhibitors on Fusarium infection of potato tubers.
CUNNINGHAM, H. S. *Phytopathology, 45,* 95-8 (1953); *Food Sci. Abstr., 27* (6), No. 2857 (1955).

Dry rot, caused by *Fusarium sp.*, was found to be more prevalent in stored potatoes that had been treated with a com. sprout inhibitor than in untreated tubers. A histological study of potato tubers of the Green Mountain variety indicated that sprout inhibitors contg. the Me ester of naphthaleneacetic acid as the active agent delayed the normal healing of cut surfaces, and the wound cork was formed irregularly, if at all. The sprout inhibitors did not prevent infection by, and subsequent growth of, *Fusarium,* since the organism continued to penetrate unless prevented by a complete layer of cork. In contrast, sprout inhibitors contg. tetrachloronitrobenzene as the active agent (Fusarex) delayed the initial formation of suberin slightly longer than in untreated tubers, but a complete layer of wound cork was present on the same day in treated and untreated tubers. If sprout inhibitors are used in excess of the amt. recommended by the manufacturer, wound cork formation is increasingly retarded.

PHYSICAL RESEARCH

The intrinsic viscosities of the water-soluble components of wheat flour.
UDY, D. C. (Field Crops Res. Branch, Pullman, Washington). *Cereal Chem., 33,* 67-74 (1956).

(Continued on page 36)

How Sunkist helps you...

In every field of food processing, new contributions are being made toward tomorrow's better foods. Look at these typical Exchange Brand developments, based on 50 years of Sunkist research.

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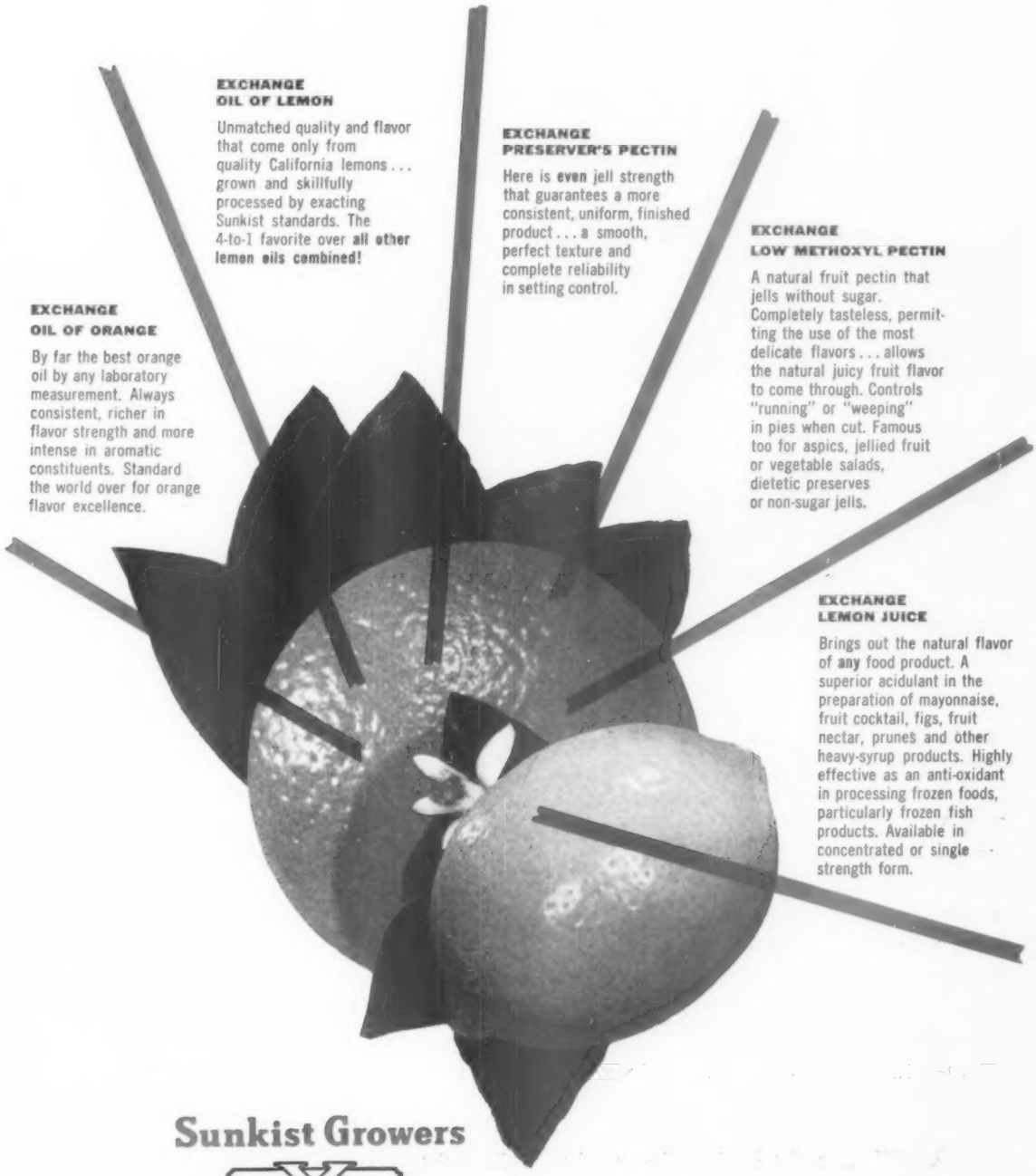

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(Continued from page 34

Viscosity measurements on the H_2O exts. of several wheat flours have shown that about 95% of the intrinsic viscosity of the ext. is due to the polysaccharides present. A large variation in both size and amt. of sol. polysaccharides was found among many pure wheat varieties of widely differing protein content and growth environment. Single varieties were fairly consistent in these properties, and some correlation is evident between these properties and cookie diameters used in quality testing.

Some aspects of the rheology of adhesives and wood.

NARAYANAMURTI, D. (Forest Res. Inst., Dehra Dun (India). *Kolloid-Z., 145*, 80-8 (1956).

A possible mechanism of gel formation is presented. The rigidity modulus of gelatin gels measured with a Saunders and Ward app. was found to vary as the sq. of the concn. Sodium chloride increased the rigidity. Rheological properties of adhesive films of gelatin, casein and prolamin were studied under a wide variety of conditions with the torsion pendulum and the interesting results reported.

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(Continued on page 69 following technical papers)

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Dielectric Scalding of Spinach, Peas, and Snap Beans for Freezing Preservation[a]

Margaret McGregor Hard[b] and Edward Ross[b]
State College of Washington, Pullman, Washington

(Manuscript received February 2, 1956)

DURING THE COURSE of extended frozen food studies in this laboratory, high frequency war-surplus radar equipment was used as a source of "dry" heat for scalding procedures. Dielectric equipment is available now commercially, and data on the relative merits of dielectric, water, and steam scalding of vegetables should be of much interest. Spinach, peas, and snap beans were selected for study. The three scalding methods were combined with water-dip, air, and spray cooling procedures. Soluble solids content, weight of processed product, pH, and nutritive retention as reflected in reduced ascorbic acid values were the criteria on which evaluation of the scalding and cooling methods was made.

A variety of set-ups and equipment has been used in applying the principle of dielectric heating to the scalding of vegetables. Kaloyereas *(4)* employed dielectric heat in a study of blanching methods for cauliflower and spinach. No description of dielectric equipment was given other than "the dielectric unit was designed for teaching purposes and had only two frequencies of 0.2 and 11 megacycles. The lower frequency had no effect."

Moyer and Stotz *(7)* and Moyer and Holgate *(8)* used an R. C. A. "radio frequency generator," operating at 150 megacycles (mc.), with a possible 750 watt output. The high frequency energy was applied to the vegetables in a package between electrodes in an auxiliary oven, thermostatically controlled at 212° F. in the usual manner. The "radio frequency blanching" of cut corn was described by Samuels and Wiegand *(13)*. These workers used a Mann-Russell Electronic Heater of three kilowatts, 3300 BTU output per hour at 27 megacycles. A polystyrene container for the corn was placed between 4¼ by 6 in. copper external electrodes.

The application of "radar energy" to the blanching of vegetables was reported by Proctor and Goldblith *(12)*. They used a Raytheon radar oven, employing a magnetron to generate the microwave energy at 3000 mc. with a power input of 2000 watts to the food. This equipment was manufactured specifically for the dielectric heating of foods. A similar oven, employing a 1,050 mc. continuous wave magnetron oscillator and manufactured by the General Electric Company, was described by Morse and Revercomb *(6)*.

Nelson *(9, 10)* reported on developmental work with the magnetron oscillator. Due to the difficulty of shielding dielectric heating equipment in the microwave range, the developmental work was confined to a frequency band assigned for dielectric heating by the Federal Communications Commission, viz., 915 mc. ± 25 mc. A rugged magnetron oscillator at this frequency was described by Nelson. The power output was 5 kw. Experimental magnetrons were built to give up to 50 kw. at 1000 mc., but tube life was measured in "tens of hours." It was concluded "from these high power tube tests that we have a good 30 kw. oscillator at 1000 mc."

At 2450 mc. (the next FCC assigned band for dielectric heating) magnetrons are available from the Raytheon Manufacturing Company.

Some of these investigators *(4, 7, 12, 13)* have evaluated the dielectric method by means of ascorbic acid and soluble solids determinations. Few have varied the cooling procedures.

MATERIALS AND METHODS

Handling of products. Improved Thick-Leaved spinch, Thomas Laxton peas, and Tendergreen snap beans grown in the Department of Horticulture gardens were used in this study. The vegetables were delivered to the food processing laboratory within an hour after harvest.

After preliminary preparation, as described by Bedford and Hard *(1)*, the vegetables were divided into 1600-1700 gram lots. Using a balanced lattice design ($k^2 = 9$) each lot provided sufficient material for 3 treatments (150 g. per portion) and duplicate samples of the fresh materials for analytical determinations. The lots or incomplete blocks were set up to remove variations due to length of holding the fresh material. Three lots or incomplete blocks were processed each day for 4 days.

Dielectric scalding. Figure 1 shows the equipment used. To the left in the background is an Army Transmitter (No. BC-407-A) and to the right a 15,000-volt war surplus rectifier (No. RA38). Figure 2 shows the parallel aluminum electrodes (4 x 8 in.) between which the load (vegetable) was placed to be dielectrically heated. In the gloved hand shown is a rectangular (4 x 4 x 2 in.) Pyrex glass container in which spinach was scalded. The container was covered by a glass lid during the

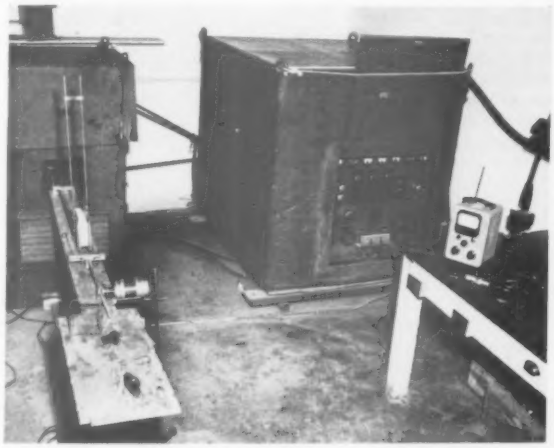

Figure 1. Equipment for the dielectric scalding of vegetables.

[a] Scientific Paper Number 1461, Washington Agricultural Experiment Stations, Pullman, Projects No. 616 and 798.

[b] Departments of Home Economics and Horticulture, respectively.

heating process. With the power output available from this equipment, it was possible to scald the 150-g. samples of spinach to a negative peroxidase test in 3 minutes.

Since the dielectric properties of the vegetable were changing while heating, it was necessary to tune the load during the scalding period in order to maintain a maximum power input to the load. This was done by moving the horizontal, telescoping,

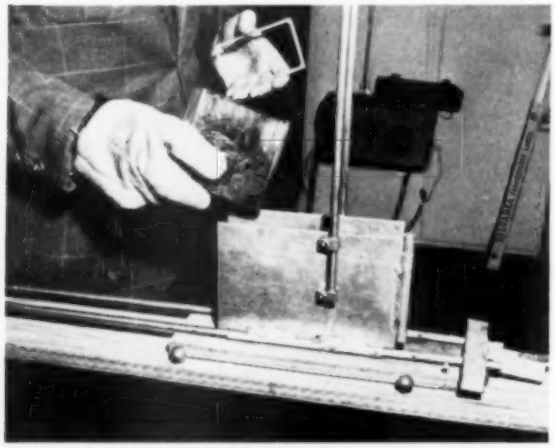

Figure 2. The parallel aluminum electrodes between which the vegetable was placed to be dielectrically heated.

brass tube transmission lines leading from the transmitter to the electrodes. The movement was controlled by a pair of Selsyn motors, the one located at the rectifier where the operator observed the plate current and adjusted the tuning to maximum. This adjustment was transmitted to the second Selsyn motor (shown in the left foreground of Figure 1) attached by a rack and pinion drive to the telescoping leads.

It was necessary to make a right angle in the transmission leads at the electrodes in order to assure a sufficiently uniform field between the electrodes. The length of the lead from the right angle of the plates to the matching stub was usually about 88 cm. The telescoping leads between transmitter and the right angle of the electrodes varied from about 107 cm. at the beginning to about 103 cm. at the end of the scalding period for maximum plate current. Since the frequency was 200 mc. (checked by a General Radio type 758-A Wavemeter) with a corresponding wave length at 150 cm., the position of the load for maximum power was approximately ¾ λ along the standing wave set up in the transmission line.

An interesting observation was made while heating spinach in early experiments before the right angle of the transmission line was imposed at the electrodes. The spinach was observed to heat and compact into definite striations which measured approximately 10 cm. apart. Assuming that this distance approximated half the wave length in the spinach mass, the velocity of propagation of the wave was

$$v = f \lambda = 20 \times 2 \times 10^8 = 4 \times 10^9 \text{ cm./sec.}$$

Where f = frequency in cycles/sec. λ = wave length in cm. Since the velocity (V) of an electromagnetic wave in any medium can be shown to be *(2)*

$$V = \frac{C}{\sqrt{KU}}$$

where C = 3×10^{10} cm./sec.
K = dielectric constant of the medium
U = permeability of the medium

the value for the dielectric constant of the spinach mass may be calculated, assuming no magnetic properties so that U = 1:

$$4 \times 10^9 = \frac{3 \times 10^{10}}{\sqrt{K}} \quad \text{and} \quad K = 56$$

Peas and cut green beans did not heat satisfactorily in the glass container. They were heated in a pliofilm bag placed in a cardboard carton as shown in place between the electrodes in Figure 1. The size of the cardboard carton was 4 x 4 x 1½ in. One hundred and fifty grams of peas were scalded to a negative peroxidase test in 3½ minutes, while 4½ minutes were required to scald 150 g. of the beans. The plate current to the oscillator was maintained at 240 ma. at a plate voltage of 9 kv. for either product. Increases in power above this usually resulted in undesirable arcing between individual peas or beans, or in arcing through the pliofilm bag. A plate current of 300 ma. at 9½ kv. could be maintained for 3 minutes during the scalding of 150 grams of spinach in the glass container.

Water and steam scalding. In the water scalding procedures, the 150-g. sample was placed in a wire basket and immersed in boiling water heated with live steam. The time for scalding was counted from the time of submersion. The spinach and peas were scalded 1½ minutes and snap beans 4 minutes.

In the steam scalding procedures, the vegetables were subjected to live steam in a steam cabinet—3 minutes for spinach and peas, 4 minutes for snap beans.

Cooling methods. After scalding, the vegetables were water-dip, air- or spray-cooled to an internal temperature of 30° C. This temperature was reached with a ½ minute for the water-dip, ¾ of a minute for the spray and 5 minutes for air cooling in front of a fan. The water-dip- and spray-cooled samples were subsequently drained for 5 minutes for spinach, 1½ minutes for peas and 1 minute for snap beans. The dielectrically scalded samples were removed from the scalding container for cooling.

Freezing and freezer storage. The scalded, cooled vegetables were packed in pint-sized polyethelene bags in cartons, quick-frozen and stored at 0° F. In closing the bags, care was taken to force out the air.

Analytical methods. Reduced ascorbic acid *(5)*, soluble solids, pH and peroxidase tests *(15)* were made immediately after cooling and after 6 months of freezer storage. Each sample was re-weighed after cooling so the ascorbic acid and soluble solids results could be corrected for weight changes in the sample.

Statistical analyses. Although the original experiment was carried out according to the plan for a balanced lattice design ($k^2 = 9$), the final analyses were completed using the simpler randomized block design. This simplification was justified since evaluation of lot (incomplete block) variation indicated that no appreciable gains in efficiency were to be expected through adherence to the original design. Duncan's Multiple range test *(3)* was employed to evaluate the significance of differences between treatment means. In presenting the results of the multiple range test, the groups of treatments were numbered; e.g., all in group 1 not significantly different from each other, all in group *2* not significantly different from each other, while those in group 1 *not* in group *2* were taken as significantly different.

Quality evaluation. In the early stages of developing a suitable means of applying the high frequency power to the vegetables, samples of the dielectrically scalded vegetables were cooked and eaten at home by the authors and by other staff members. These were considered to be comparable to steam and hot-water-blanched vegetables, except where arcing had occurred in the dielectrically-heated samples. Thus, the chief concern was to provide conditions which would eliminate arcing. A quantitative quality evaluation was not incorporated in the statistical design, but dielectrically-heated samples were evaluated qualitatively for color and appearance, particularly, pinpointing due to arcing. This effect was not observed in any spinach or pea samples. Arcing did occur occasionally in some bean samples, but usually without a noticeable effect on appearance.

RESULTS AND DISCUSSION

The peroxidase values were negative for all treatments immediately after cooling and after 6 months' freezer storage.

No differences in pH values appeared in the pea and snap bean treatments. With spinach, the water—water-dip and water—spray scalding-cooling treatments were consistently higher in pH than the fresh product. This was probably due to the adherence of water to the spinach leaves.

Weight retention. Although there are some slight variations among the vegetables, the greatest weight losses occurred with the dielectric-air treatment (Tables 1, 2 and 3). These losses were not significantly different from those in the other air-cooling treatments but were significantly greater than the losses in water and spray cooling (Table 4). Where water or spray cooling was involved, there was no significant weight change. Moyer and Holgate *(8)* also found weight losses in air-cooling but little if any loss with water-cooling.

TABLE 1

Mean retentions of reduced ascorbic acid, soluble solids and weight in frozen spinach

Treatment	Reduced ascorbic acid[a] (%)		Soluble solids[a] (%)		Weight (%)
Scald-cool	Immed.	6 mo.	Immed.	6 mo.	Immed.
Water-water dip	71.1	55.06	36.98	46.40	102.83
Water-air	85.4	58.52	43.38	48.28	96.00
Water-spray	46.8	40.05	38.92	39.88	93.61
Steam-water dip	86.4	66.53	76.22	50.20	102.44
Steam-air	86.4	68.96	59.38	52.90	92.00
Steam-spray	72.8	58.44	39.38	44.35	96.89
Dielectric-water dip	79.5	59.75	41.80	46.15	93.94
Dielectric-air	89.0	70.73	63.38	59.82	85.06
Dielectric-spray	72.4	62.45	42.48	43.28	93.40
Standard error of the mean	6.69	4.25	9.37	1.64	3.11

[a] Corrected for weight changes in the sample.

Ascorbic acid and soluble solids retention. The treatment means for reduced ascorbic acid and soluble solids are given in Tables 1, 2 and 3. These values have been corrected for weight changes in the sample. The least significant range groups for these means are given in Table 4. Any 2 means not in the same group are significantly different.

TABLE 2

Mean retentions of reduced ascorbic acid, soluble solids and weight in frozen peas

Treatment	Reduced ascorbic acid[a] (%)		Soluble solids[a] (%)		Weight (%)
Scald-cool	Immed.	6 mo.	Immed.	6 mo.	Immed.
Water-water dip	68.47	49.93	71.22	58.60	100.45
Water-air	65.78	50.66	65.10	61.82	87.50
Water-spray	78.26	38.91	62.38	56.82	101.00
Steam-water dip	68.63	52.59	66.10	62.38	102.11
Steam-air	73.11	57.63	71.48	65.92	86.05
Steam-spray	72.44	44.63	65.20	59.60	102.94
Dielectric-water dip	83.69	64.73	71.00	69.42	98.11
Dielectric-air	93.41	79.65	78.10	77.70	85.58
Dielectric-spray	78.49	72.74	68.25	64.82	99.78
Standard error of the mean	6.40	4.60	8.44	2.01	4.22

[a] Corrected for weight changes in the sample.

In frozen *spinach* the retention of ascorbic acid was significantly lower in the water-spray treatment, both initially and after freezer storage. Initially, there were no differences among the other treatments. After 6 months' storage, an advantage of dielectric-air over water-water-dip and water-spray had appeared.

A significantly higher retention of ascorbic acid was found again in the dielectric air treatment of *peas*. Also apparent was a lower retention in the water and spray cooling treatments.

In *snap beans*, the water-spray scalding-cooling method resulted in significantly lower ascorbic acid retention initially, but there were no differences among the treatments after storage.

At the extremes, the soluble solids results tend to bear out the ascorbic acid losses particularly following storage. It will be noted (Table 1, 2 and 3) that the soluble solids contents of water-spray spinach, peas and snap beans were lower (but not significantly so) and the dielectric-air spinach and peas significantly higher than the soluble solids of the other treatments. Loss of ascorbic acid through oxidation as well as leaching is apparent in the lack of a closer relationship between ascorbic acid and soluble solids losses.

TABLE 3

Mean retentions of reduced ascorbic acid, soluble solids and weight in frozen snap beans

Treatment	Reduced ascorbic acid[a] (%)		Soluble solids[a] (%)		Weight (%)
Scald-cool	Immed.	6 mo.	Immed.	6 mo.	Immed.
Water-water dip	81.56	59.03	84.30	66.05	100.84
Water-air	85.28	64.06	82.85	64.98	91.03
Water-spray	67.52	68.73	83.90	64.58	100.56
Steam-water dip	108.72	72.94	90.10	69.22	100.06
Steam-air	96.62	70.10	88.30	69.48	89.66
Steam-spray	90.99	74.87	88.08	71.40	99.06
Dielectric-water dip	93.22	72.26	90.68	73.05	94.72
Dielectric-air	98.17	71.42	90.58	75.28	85.11
Dielectric-spray	90.15	64.40	88.58	72.38	95.83
Standard error of the mean	3.66	5.75	7.36	1.87	3.21

[a] Corrected for weight changes in the sample.

These ascorbic acid retentions are in general agreement with those reported by Moyer and Stotz *(7)*, Proctor and Goldblith *(12)*, and Samuels and Wiegand *(13)*. However, they do not show as decisive an advantage for the dielectric scalding method as has been indicated by these reports. Kaloyereas *(4)* found dielectric heat satisfactory in saving soluble solids but not for retention of ascorbic acid.

The dielectric method. With the arrangement and equipment used in this study, the power dissipation by the plates was of the order of magnitude of 2½ kw. with a corresponding energy of 0.125 kw. hours, equivalent to 427 BTU. Since this would be sufficient to completely boil off nearly a ½ pound of water, the efficiency of energy exchange was exceedingly low. However, with the power conversion efficiency of 56% for equipment operating at a lower frequency and the future possibility of achieving a 75% conversion efficiency *(11, 14)*, the practical application of dielectric heat in commercial food freezing would become feasible in the light of very efficient heat transfer.

TABLE 4

Least significant range groups for means [a]

Range [b] group	Reduced ascorbic acid		Soluble solids [c]	Weight
	Immed.	6 mo.	6 mo.	Immed.
Spinach				
1	WS [d]	WS [d]	WS,SS,DS [d]	DA,SA,WS,DW,DS [d]
2	WW,WA,SW,SA,SS,DW,DS,DA	WW,WA,SW,SA,SS,DW,DS,	SS,DS,WW,WA,DW	SA,WS,DW,DS,WA,SS
3		WA,SW,SA,SS,DW,DS,DA	WW,WA,DW,SW	WS,DW,DS,WA,SS,WW,SW
4			SW,SA	
5			DA	
Peas				
1	WS,WA,WW,SW,SA,SS,DW,DS	WS,WW,SS,SW,WA	WS,WW,WA,SW,SS	DA,SA,WA,DW
2	SA,WS,DW,DS,DA	SW,WA,SA,DW	WW,WA,SW,SS,DS	WA,DW,WW,WS,DS
3		DW,DS	WA,SW,SS,DS,SA	DW,WW,WS,DS,SW,SS
4		DA	DS,SA,DW	
5			DA	
Snap beans				
1	WS	No significant difference	WS,WA,WW,SW,SA	DA,SA,WA,DW
2	WW,WA,SS,DW,DS	between treatments.	WW,SW,SA,SS	SA,WA,DW,SW,SS,DS
3	WA,SS,DW,DS,SA		SW,SA,SS,DW,DS	WA,DW,SW,SS,DS,WW,WS
4	SW,DA		SA,SS,DW,DS,DA	
5				

[a] Any 2 means not in the same group are significantly different.
[b] Mean values range from lowest to highest in groups 1 to 5.
[c] No significant difference between treatments mean immediately after freezing.
[d] Scalding-cooling treatments: WW, water-water dip; WA, water-air; WS, water-spray; SW, steam-water dip; SA, steam-air; SS, steam-spray; DW, dielectric-water-dip; DA, dielectric-air; DS, dielectric-spray.

SUMMARY AND CONCLUSIONS

Dielectric, water and steam scalding of spinach, peas, and snap beans are compared. The three scalding methods were combined with water-dip, air- and spray-cooling procedures. Reduced ascorbic acid values, soluble solids, pH and weight of the processed products were the criteria used for evaluation. The ascorbic acid and soluble solids results were corrected for weight changes in the samples. The following conclusions may be drawn:

1. The combination of water scald and spray cooling resulted in a significantly lower retention of reduced ascorbic acid and soluble solids in spinach and peas and initially in snap beans.

2. The dielectric scald-air cool treatment gave higher retentions of reduced ascorbic acid, particularly with peas. Significantly higher retention of soluble solids was evident with this procedure.

3. The greatest weight losses occurred in the air-cooling treatments.

4. With the methods employed in this study, the dielectric scalding procedures did not show a clear-cut advantage over water and steam methods combined with water-dip and air-cooling.

Acknowledgment

The authors gratefully acknowledge the valuable advice on electronic principles and practice given by Brendan Byrne and C. B. Jones; the technical assistance of Art Warner and May C. Titus; and the statistical advice of J. G. Darroch.

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Post Mortem Changes in the Interactions Of Cations and Proteins of Beef and Their Relation to Sex and Diethylstilbestrol Treatment[a]

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(Manuscript received February 18, 1956)

IN AN EARLIER PAPER from this laboratory *(12)* a number of post mortem changes in the meat were observed which led to the suggestions that post mortem tenderization may be related to dissociation of actomyosin and/or that a redistribution of ions takes place in muscle (meat) on aging in such a way as to cause increased hydration of protein and hence improved tenderness. A detailed biochemical study has been carried out on a number of carcasses so that the suggested hypotheses might be tested more fully.

Part of the results of this study have been reported in a more recent paper *(11)*. While the toughening of meat associated with the onset of *rigor mortis* is due to the formation of actomyosin, it was found that actomyosin is not dissociated into actin and myosin on post mortem aging and thus is not responsible for post mortem tenderization.

This paper *(11)* also reports changes in pH and juice expressed on cooking over a thirty-day period. The pH drops rapidly after slaughter and reaches a minimum after three days and then gradually increases. Along with these pH changes are changes in juice expressed on cooking. During the first twenty-four hours the amount of juice released rapidly increases to a maximum and then gradually decreases. The fact that the pH minimum does not strictly coincide with the juice maximum and that the changes in juice are large compared to pH shifts after three days post mortem indicates that biochemical factors other than pH alone may be controlling protein hydration.

In the light of the work of many in the field of biochemistry and physiology which indicates that the proteins and ions in functioning muscle appear to be in a high state of organization, it may be that after the onset of *rigor mortis* random diffusion and redistribution of ions take place. The ionic shifts may be related to the degree of hydration of the muscle protein, and thereby related to tenderness since it is known that the degree of hydration is related to tenderness.

A study of the post mortem movements of sodium, potassium, magnesium, and calcium was undertaken in an attempt to learn the exact role of these cations in relation to the muscle plasma and post mortem tenderization.

Also brought out in this paper is the question of whether there is any significant relationship between post mortem cationic shifts and sex, castration, and diethylstilbestrol treatment of the animal.

[a] Published with the approval of the Associate Director of the Ohio Agricultural Experiment Station. Journal Article No. 37-56.

EXPERIMENTAL

Methods. The 32 animals described in the preceding paper *(11)* were used, with the same grouping and animal numbers. Sodium, potassium, magnesium, and calcium were determined at 3 and 13 days post mortem in the meat ash, juice expressed on cooking, and water extract. Except as noted below, the sampling techniques and the methods used have been reported previously *(4, 8, 11)*.

Moisture. The 12.5-g. meat samples in duplicate were dried in platinum dishes for 6 hours at 104-106° C.

Ash. The charred meat samples used in the moisture determination were ashed at 575° C. to constant weight.

Chromatographic separation of sodium, potassium, magnesium, and calcium. A modification of the method of Sutton and Almy *(9)* was used. Dowex 50-x 12, colloidal mesh cation exchange resin was used as the absorbent. The length of the column (approximately 23 mm. in diameter) was reduced from 65 cm. originally used to 10 cm. The column was washed out with 1 N HCl before each use.

Fifty ml. of water extract or 10-15 ml. of the juice obtained on cooking was evaporated to dryness, charred, and ashed. The ash was dissolved with 1 N.HCl and transferred quantitatively to a 25 ml. volumetric flask using 0.1 N.HCl as a washing solution. After filling to the mark, 5 ml. (juice) or 10 ml. (water extract) of the ash solutions was used for the chromatography.

The duplicate ashed meat samples were dissolved with HCl as above and combined before diluting to 25 ml. Five ml. samples (equivalent to 5 g. of meat) were used for the chromatographic determination of the total cationic content of meat.

The cations were eluted from the column by 210 ml. of 1 N.HCl followed by 300 ml. of 2.5 N.HCl with the following results:

1st fraction: 0-100 ml. was discarded.

2nd fraction: 101-210 ml. contained sodium.

3rd fraction: 211-220 ml. was blank—used to check accuracy of column.

4th fraction: 221-370 ml. contained potassium plus magnesium in a mixture.

5th fraction: 371-500 ml. contained calcium—discarded because the amounts of calcium obtained from the sample sizes used were in the range of experimental error.

The collected fractions were evaporated to dryness and the residues (metallic chlorides) were titrated for chlorides with 0.01 N.$AgNO_3$ solution using potassium chromate as an indicator.

Calcium determination. Two ml. of saturated ammonium oxalate was added to 25 ml. of the water extract, and 1 ml. of the oxalate was added to 3 ml. of the juice in order to find the free calcium. The total calcium in the muscle was determined by using in duplicate 5 ml. of the meat ash solutions. The calcium oxalate was precipitated overnight, separated from the supernatant by centrifugation, washed with 5 ml. of distilled water, dissolved by 5 ml. of 3 N.H_2SO_4, warmed, and titrated with 0.002 N.$KMnO_4$ solution.

Magnesium determination. A volumetric method, originally used by Biedermann and Schwarzenbach *(1)* and Flaschka and Holasek *(5)* for the determination of magnesium in blood serum,

was selected for this particular study. The method is based on the ability of ethylenediamine tetraacetic acid (titration reagent) to form stable metal chelate compounds with alkaline earth ions. The azo dye, Eriochrome-black T, is used as the indicator. This dye forms a wine-red complex with magnesium which is broken down by the titration reagent changing the color to blue, the color of the indicator.

The necessary reagents for this method were obtained from the Bersworth Chemical Company, Framingham, Massachusetts under the trade name "Versenes." The reagents were prepared essentially as described in the technical bulletin *(10)* supplied by the company. All reagents were prepared with double glass distilled water.

For the determination of total magnesium in meat, the following reagents were added in order to 1 ml. of the meat ash solution: 5 ml. double distilled water, 2 drops of 1 N.NH_4OH, 10 ml. buffer solution (1 part 1.0 M.NH_4Cl and 5 parts 1.0 M.NH_4OH), and 2 drops of indicator. The mixture was titrated immediately with 0.002 *N* Versenate solution, giving the total amount of magnesium plus calcium. Since the 1 ml. samples were considered too small for separation of calcium oxalate, the amount of magnesium was obtained by subtracting one-fifth of the 0.002 N.$KMnO_4$ titration value for calcium, obtained previously using 5 ml. of meat ash solution, from the Versenate titration value for magnesium plus calcium.

The sample size of 1 ml. (equivalent to 1 g. of fresh meat) is essential in order to finish the titration within 2 minutes after addition of the indicator. Otherwise, no end point can be obtained because the meat ash appears to contain some heavy metals which form a stable red complex with the dye about 3 minutes after its addition. Further investigation showed that it is also necessary to do the titration immediately after addition of the buffer because some of the magnesium apparently precipitates as $MgNH_4PO_4$, thus escaping the titration.

Magnesium in the water extracts and juice was determined by placing 5 ml. of the ash solutions of the water extracts and juice into 40 ml. centrifuge tubes (in duplicate) along with 1 drop of 0.5% methyl red in alcohol and 1 N.NH_4OH until the color of the indicator turned yellow. One additional drop of NH_4OH was added followed by enough 5% CH_3COOH to turn the indicator slightly red. The tubes were heated in a water bath; 1 ml. of the saturated ammonium oxalate was added, the tubes were cooled in an ice bath and then placed in a cold room overnight. The following day the supernatant containing magnesium was separated from the residue of calcium oxalate by centrifugation at room temperature. Residues were washed once with 5 ml. of double distilled water and centrifuged again. Washings were combined with the corresponding supernatant solutions and titrated for magnesium with the 0.002 *N* Versenate solution as described previously.

The residues (calcium oxalate) were dissolved in dilute H_2SO_4 and titrated with the 0.002 N.$KMnO_4$ to find the total calcium in the water extract and the juice.

RESULTS AND DISCUSSION

The shifts of sodium, potassium, magnesium, and calcium in the meat of a young steer between 2 hours and thirty days post mortem are represented in Figures 1-5. Data of a second steer are similar and some of these data are shown in Figures 4 and 5. Potassium and magnesium are included together in Figures 1 and 2 due to the chromatographic procedure. The cations follow essentially the same pattern in the water extract and in the juice.

Calcium and sodium are continuously released by the muscle proteins during post mortem aging. However, calcium is released at a much greater rate than sodium. There is a gradual decrease in the amount of potassium ions in the extract and juice over the 30-day period.

The changes of magnesium are rather violent and not very regular. There is a very rapid increase of magnesium, particularly in the water extract, in the earlier hours post mortem. This is followed by some kind of rearrangement between 6 and 13 days with a gradual decrease thereafter.

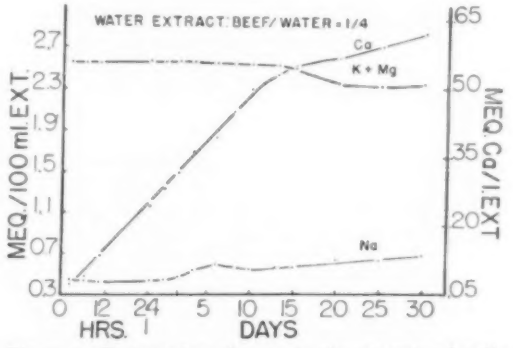

Figure 1. Post mortem changes in the amounts of sodium, calcium, and potassium plus magnesium in the water extracts of the meat.

The determination of the cation composition of the water extracts and juices at 3 and 13 days post mortem of 32 different carcasses confirms the shifts of sodium, potassium, magnesium, and calcium described above. For each carcass without exception sodium and calcium are released by the meat proteins between 3 and 13 days, and potassium is absorbed. There is no difference in

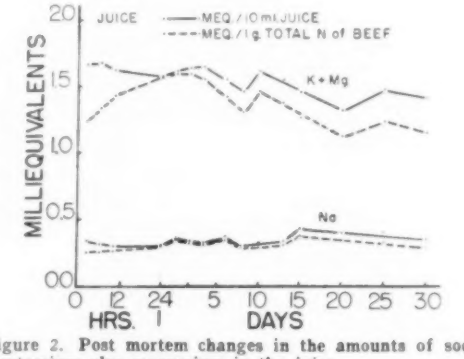

Figure 2. Post mortem changes in the amounts of sodium and potassium plus magnesium in the juice.

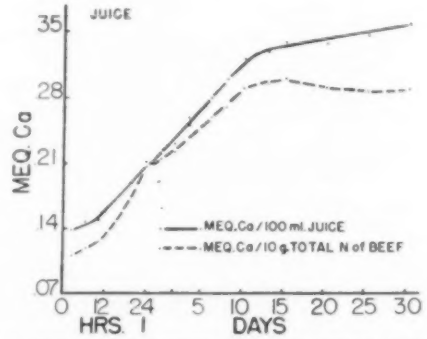

Figure 3. Post mortem changes in calcium content in the juice.

the amount of magnesium at these two times. This agrees with Figure 5 which shows that the amount of magnesium is at the same level at 3 and 13 days. These results are shown in Tables 1 and 2 which give the

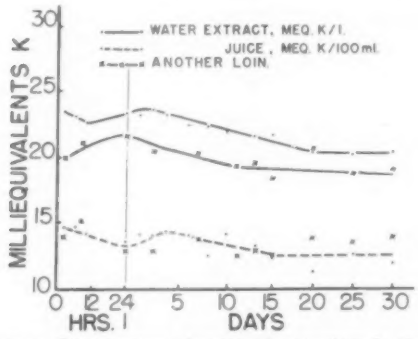

Figure 4. Post mortem changes of potassium in the water extracts and juice.

mean, standard deviation, and standard error of each cation at 3 and 13 days for each group of cattle in the water extract and juice respectively.

Also given in Tables 1 and 2 is the shift of each ion between 3 and 13 days and the total cationic shift for

TABLE 1

Cationic shifts in water extracts of meat with post mortem aging as measured at 3 and 13 days
Meat : Water = 1 : 4

	Milliequivalents/100 ml. extract									
	Na		K		Mg		Ca			
							Ionic	Total	Ionic	Total
	3	13	3	13	3	13	3	3	13	13
	1. Heifers									
Mean		.555		2.34		.374			.0447	.0748
St. Dev.		.070		0.12		.037			.0100	.0244
St. Error		.028		0.05		.015			.0041	.0122
	2. Regular bulls									
Mean	.457	.587	2.42	2.14	.368	.369	.0434	.0593	.0597	.0679
St. Dev.	.075	.024	0.12	0.19	.005	.002	.0053	.0082	.0065	.0060
St. Error	.034	.011	0.05	0.09	.002	.001	.0024	.0037	.0029	.0027
Cationic shift[1]	+0.130		−0.28		+0.001		+0.0163[2]		+0.0086[3]	
	3. Bulls implanted with diethylstilbestrol									
Mean	.382	.558	2.49	2.24	.347	.381	.0419	.0621	.0662	.0819
St. Dev.	.029	.067	0.17	0.13	.015	.017	.0028	.0129	.0099	.0096
St. Error	.013	.030	0.08	0.06	.006	.007	.0013	.0058	.0044	.0043
Cationic shift[1]	+0.176		−0.25		+0.034		+0.0243		+0.0198	
	4. Regular steers									
Mean	.416	.553	2.17	1.93	.385	.373	.0438	.0686	.0579	.0875
St. Dev.	.044	.064	0.18	0.12	.057	.046	.0061	.0085	.0043	.0152
St. Error	.013	.019	0.05	0.04	.017	.014	.0018	.0035	.0013	.0062
Cationic shift[1]	+0.137		−0.25		−0.012		+0.0141		+0.0189	
	5. Steers implanted with diethylstilbestrol									
Mean	.439	.556	2.29	1.92	.369	.355	.0425	.0817	.0549	.1032
St. Dev.	.017	.020	0.22	0.16	.024	.033	.0017	.0152	.0042	.0181
St. Error	.007	.009	0.10	0.07	.011	.015	.0008	.0068	.0019	.0081
Cationic shift[1]	+0.117		−0.374		−0.014		+0.0124		+0.0215	

[1] Total cationic shift: considering only total calcium is −0.140, −0.022, −0.105, and −0.249 for the regular bulls, implanted bulls, regular steers, and implanted steers respectively.
[2] Ionic calcium.
[3] Total calcium.

TABLE 2

Cationic shifts in juice during meat shrinkage with post mortem aging as measured at 3 and 13 days

	Milliequivalents/100 ml. juice							
	Na		K		Mg		Ca	
	3	13	3	13	3	13	3	13
	1. Heifers							
Mean		3.29		14.92		2.19		.406
St. Dev.		0.53		1.94		0.24		.094
St. Error		0.22		0.79		0.10		.039
	2. Bulls							
Mean	2.67	3.39	14.78	13.42	2.11	2.10	.255	.317
St. Dev.	0.25	0.43	0.88	0.99	0.08	0.10	.035	.037
St. Error	0.11	0.19	0.40	0.45	0.04	0.04	.016	.017
Cationic Shift[1]	+0.72		−1.76		−0.01		+0.062	
	3. Bulls implanted with diethylstilbestrol							
Mean	2.61	3.73	15.32	13.96	2.20	2.21	.230	.274
St. Dev.	0.15	0.45	0.41	1.29	0.17	0.16	.044	.053
St. Error	0.07	0.20	0.18	0.58	0.08	0.07	.020	.024
Cationic Shift	+1.12		−1.36		+0.01		+0.044	
	4. Steers							
Mean	2.83	3.91	14.36	13.02	2.26	2.31	.408	.528
St. Dev.	0.39	0.37	0.54	1.19	0.23	0.20	.079	.087
St. Error	0.12	0.11	0.16	0.36	0.06	0.06	.024	.026
Cationic Shift	+1.08		−1.34		+0.05		+0.120	
	5. Steers implanted with diethylstilbestrol							
Mean	2.84	3.95	14.28	13.52	2.20	2.16	.454	.500
St. Dev.	0.42	0.31	0.54	0.55	0.15	0.23	.068	.085
St. Error	0.19	0.14	0.25	0.25	0.07	0.10	.030	.038
Cationic Shift	+1.11		−0.76		−0.04		+0.046	

[1] Total cationic shift is −0.99, −0.19, −0.09, and +0.40 for the regular bulls, implanted bulls, regular steers, and implanted steers respectively.

each group. It will be noted that with only one exception the total cationic shift is a movement of ions into the meat proteins. This is due to the large amount of potassium ions being taken up in relation to the amount of sodium and calcium being released. The result of this movement of ions is that the muscle proteins become more positively charged.

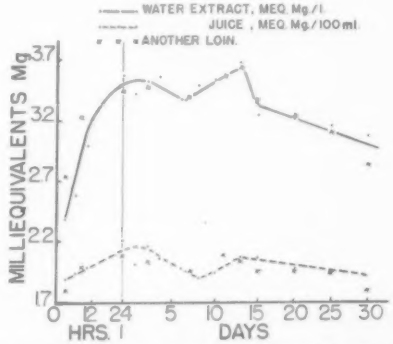

Figure 5. Post mortem changes of magnesium in the water extracts and juice.

The electrical charge on the protein body may well be the factor which is responsible for the water binding capacity of fresh meat. This idea is discussed quite well in a paper by Hamm *(7)*. Each protein has an isoelectric point at which the positive and negative charges nullify each other and are not available for the binding of the water dipole. This means that at the isoelectric point, hydration of the protein is at a minimum.

If the overall charge on the protein increases, the degree of hydration correspondingly increases.

This is apparently what happens to meat during the aging process. When *rigor mortis* has developed, the meat is least tender, the degree of hydration is at a minimum, and the pH is at its lowest point (about 5.4), which is the isoelectric point of myosin and actomyosin. In the following days there is an increase in charge due to the uptake of potassium ions. The result is a greater degree of hydration accompanied by increased tenderness. The pH also increases.

The continuous but relatively slow release of sodium is apparently due to a displacement by potassium ions. Since both sodium and potassium are monovalent, the reason for displacement must be something other than valence, possibly differences in mass.

Another specific effect on hydration and tenderness can be attributed to the release of calcium. Since calcium promotes precipitation and dehydration of myosin and actomyosin, its continuous release by the muscle could be responsible to some extent for the increase of hydration of the actomyosin complex.

It is possible that a part of the calcium released during post mortem aging is precipitated in the muscle itself, perhaps as insoluble calcium orthophosphate. The removal of free orthophosphoric acid, which is formed during the enzymatic breakdown at ATP in the first few hours post mortem, could be one reason for the subsequent increase in pH.

These explanations for the effect of the release of calcium agree with the information in the papers by Grau *et al. (6)* and Bozler *(2, 3)*.

The release of magnesium during the first 24 hours post mortem occurs simultaneously with the formation of the actomyosin complex and the breakdown of ATP. The apparent rearrangement of the magnesium ions and the proteins between 6 and 13 days cannot be explained.

Table 3 shows relatively the same results as above when the amounts of cations in the water extracts and juice are calculated as per gram of total nitrogen. In the juice, there also appears to be a slight decrease in magnesium between 3 and 13 days.

An interesting point in Table 3 is the fact that less than one-third as many cations are found in the juice as in the water extracts. The polarity of water results in the extraction of many of the loosely bound cations which are not released with the juice during the heating process.

Even such a strong extractant as water fails to remove about 15% of the magnesium from the meat. This is shown by comparing the amount of magnesium extracted (Table 3) with the total amount present in the meat (Table 4). This remaining magnesium is evidently very tightly bound, perhaps in some manner to the actomyosin complex.

Table 4 gives a picture of the total cationic composition of muscle and percent ash of the 5 groups of cattle. Various comparisons can be made, but the number of animals in each group and the differences in cation composition following castration and diethylstilbestrol treatment are too small to draw any definite conclusions. There may be some significance in the fact that the heifers have a noticeably smaller percent of ash on a fat and moisture free basis than the other 4 groups of cattle.

TABLE 3

Post mortem cationic shifts in the water extract and juice per 1 gram of the total N of the muscle

Cation	Water extracts			Juice		
	Milliequivalents/g. total N			Milliequivalents/g. total N		
	3 days	13 days	Shift	3 days	13 days	Shift
	1. Heifers (n = 6)					
Na	.....	0.726	.....	.....	0.215	.....
K	.....	3.207	.....	.....	0.974	.....
Mg	.....	0.516	.....	.....	0.143	.....
Ca[1]	.....	0.103	.....	.....	0.024	.....
Total	.....	4.552	.....	.....	1.356	.....
	2. Regular bulls (n = 5)					
Na	0.624	0.802	+.178	0.221	0.259	+.038
K	3.311	2.929	−.382	1.224	1.028	−.196
Mg	0.502	0.504	+.002	0.175	0.160	−.015
Ca	0.081	0.092	+.011	0.921	0.024	+.003
Total	4.518	4.327	−.191	1.641	1.471	−.170
	3. Bulls implanted with diethylstilbestrol (n = 5)					
Na	0.514	0.751	+.237	0.181	0.277	+.096
K	3.359	3.019	−.340	1.201	1.032	−.169
Mg	0.467	0.513	+.046	0.172	0.164	−.008
Ca	0.084	0.110	+.026	0.018	0.020	+.002
Total	4.424	4.393	−.031	1.572	1.493	−.079
	4. Regular steers (n = 11)					
Na	0.572	0.746	+.174	0.221	0.247	+.026
K	2.990	2.651	−.339	1.128	0.927	−.201
Mg	0.528	0.513	−.015	0.178	0.164	−.014
Ca	0.094	0.120	+.026	0.032	0.038	+.006
Total	4.184	4.030	−.154	1.559	1.376	−.183
	5. Steers implanted with diethylstilbestrol (n = 5)					
Na	0.598	0.758	+.160	0.230	0.292	+.062
K	3.125	2.616	−.509	1.163	1.004	−.159
Mg	0.502	0.483	−.019	0.179	0.160	−.019
Ca	0.111	0.141	+.030	0.037	0.037	.000
Total	4.336	3.998	−.338	1.609	1.493	−.116
	Cationic shifts for the entire group (3 days n = 27; 13 days n = 32)					
Na	0.580	0.754	+.174	0.215	0.261	+.046
K	3.162	2.819	−.343	1.164	0.980	−.184
Mg	0.506	0.508	+.002	0.176	0.159	−.017
Ca	0.092	0.114	+.022	0.028	0.030	+.002
Total	4.340	4.195	−.145	1.583	1.430	−.153

[1] Only total Ca is considered.

Table 5 includes a summary of part of the results and significant correlation coefficients of cation content with tenderness at 3 and 13 days post mortem. The percent ash on a fat and moisture free basis at 3 and 13 days and on a wet basis at 3 days shows a significant negative correlation with tenderness. This fact cannot be explained.

With the exception of the results given in Table 5, there appeared to be only a very small correlation between tenderness and the absolute amounts of each cation at 3 and 13 days in the muscle, in the water extract, and in the juice.

In general it may be said that the importance of cations to water-holding capacity and tenderness of meat is not due to the total amount of each cation, but to their combined effect and to the movements of the ions during post mortem aging.

TABLE 4

Effect of sex on ash, and sodium, potassium, magnesium, and calcium contents of Longissimus dorsi muscle of cattle

Animal no.	Wet basis	Ash, % Fat and moisture free	Milliequivalents/g. total N Na	K	Mg	Ca
			1. Heifers			
10	1.03	4.21	.613	2.76	.557	.0854
7	1.01	4.03	.739	2.82	.587	.0892
6	1.09	4.38	.756	2.84	.586	.0962
8	1.06	3.87	.693	2.83	.580	.0777
9	1.10	4.20	.670	2.62	.602	.1610
1	0.99	3.61	.874	2.67	.489	.1081
Mean	1.05	4.05	.724	2.76	.567	.1029
St. Dev.	0.04	0.28	.089	0.09	.041	.0303
St. Error	0.02	0.11	.037	0.04	.017	.0124
Mean, mg. %			56.3	365.	23.3	6.93
			2. Regular Bulls			
32	1.06	4.12	.555	2.92	.615	.1172
30	1.17	4.73	.630	3.14	.648	.0970
29	1.14	4.65	.521	3.09	.619	.0705
31	1.13	4.49	.568	3.16	.626	.1023
3	1.05	4.39	.805	3.03	.580	.0744
Mean	1.11	4.48	.616	3.07	.618	.0923
St. Dev.	0.05	0.24	.113	0.10	.024	.0196
St. Error	0.02	0.11	.050	0.04	.011	.0088
Mean, mg. %			49.0	415.0	26.0	6.29
			3. Bulls Implanted with Diethylstilbestrol			
27	1.11	4.51	.548	3.12	.591	.0827
5	1.09	4.52	.818	2.92	.565	.1051
16	1.10	4.40	.521	2.70	.532	.1429
17	1.13	4.50	.527	2.65	.566	.1002
28	1.13	4.38	.587	2.75	.576	.0792
Mean	1.11	4.46	.606	2.83	.566	.1020
St. Dev.	0.02	0.07	.138	0.19	.022	.0254
St. Error	0.01	0.03	.062	0.09	.010	.0114
Mean, mg. %			48.8	389.0	24.2	6.78
			4. Regular Steers			
41	1.05	4.37	.612	2.81	.541	.1182
42	1.03	4.18	.624	2.89	.615	.0824
44	1.10	4.56	.620	3.27	.667	.0830
39	1.03	4.37	.673	2.76	.601	.1161
40	1.06	4.62	.598	2.91	.751	.0953
19	1.06	4.25	.619	2.98	.550	.0787
14	1.07	4.13	.568	2.92	.741	.1213
18	1.00	4.27	.633	2.79	.547	.0944
43	1.12	4.38	.586	3.26	.568	.1260
4	1.07	4.29	.891	2.74	.597	.1093
20	1.04	4.35	.602	2.77	.542	.0840
Mean	1.06	4.40	.639	2.92	.611	.1008
St. Dev.	0.93	0.22	.088	0.19	.077	.0178
St. Error	0.01	0.07	.027	0.06	.023	.0054
Mean, mg. %			50.0	388.0	25.2	6.85
			5. Steers Implanted with Diethylstilbestrol			
11	1.12	4.29	.602	3.00	.600	.0786
2	1.04	4.33	.810	3.06	.595	.1209
15	1.10	4.18	.545	2.94	.528	.0889
12	1.08	4.43	.618	3.35	.559	.1151
13	1.11	4.36	.704	3.18	.592	.1388
Mean	1.09	4.32	.656	3.11	.575	.1085
St. Dev.	0.03	0.10	.103	0.16	.031	.0245
St. Error	0.01	0.04	.046	0.07	.014	.0109
Mean, mg. %			52.0	419.	24.1	7.47

The entire picture concerning post mortem improvement in tenderness is very complex. The degree of hydration and the pH of the meat are definitely related to tenderness. Most of the phenomena which are connected with the water binding of muscle can be traced back to the kind and number of the electrical charges which exist in the protein. The movements of the cations on and off the protein surfaces bring about changes in the electrical charges, and therefore it is reasonable to say that the cationic shifts are an important factor in this problem of understanding the nature of tenderness.

From a practical standpoint such problems as shrink on cooking, texture, drip on thawing of frozen meat, taste, juiciness, and color as well as tenderness may be related to the ion-protein interactions, primarily through the effect of these interactions on the degree of hydration of the meat. Through the knowledge of the movement of the cations and their significance, various practical applications can be adopted which will improve the production and quality of the meat.

TABLE 5

Summary of the results

Quality factor	No. of animals	Mean	Standard deviation	Standard error	r[1]	Probability
Tenderness						
3 days	27	5.51	1.15	0.22	.....	.....
13 days	32	7.39	0.75	0.13	.....	.....
Percent Ash Wet Basis	32	1.076	0.044	0.008	−0.404[2]	0.05-0.02
					+0.054	>0.5
Fat and Moisture Free	32	4.342	0.243	0.043	−0.737[2]	<0.01
					−0.670	<0.01
Cation: milliequivalents/g. total N						
Na	32	0.619	0.104	0.018	−0.017[2]	>0.5
					−0.613	<0.01
K	32	2.927	0.194	0.034	−0.128[2]	>0.5
					−0.076	>0.5
Mg	32	0.591	0.054	0.010	+0.262[2]	0.2-0.1
					+0.241	0.2-0.1
Ca	32	0.1013	0.022	0.004	−0.010[2]	>0.5
					−0.287	0.2-0.1
Cation: milliequivalents/100 ml. Extract						
Na 3 days	27	0.424	0.051	0.010	−0.029	>0.5
K 3 days	27	2.314	0.211	0.041	−0.388	0.05-0.02
Mg 3 days	27	0.370	0.040	0.008	+0.364	0.1-0.05
Ionic Ca 3 days	27	0.0436	0.005	0.001	+0.361	0.1-0.05
Cation: milliequivalents/100 ml. Juice						
Mg 13 days	32	2.215	0.082	0.015	+0.388	0.05-0.02
Total Ca 3 days	27	0.355	0.108	0.021	+0.413	0.05-0.02

[1] Correlation coefficient with tenderness.
[2] Correlation coefficient with tenderness at 3 days ($n = 27$).

One procedure already in use is the addition of salt to the meat. From the results presented in this study, it can be stated that the addition of any electrolyte which will increase the overall charge of the meat proteins or will render insoluble the calcium ions of the meat will lead to an increased hydration and tenderness of the meat.

SUMMARY

A study of the post mortem movements of the sodium, potassium, magnesium, and calcium in beef was undertaken in an attempt to learn the exact role of these cations in relation to the muscle plasma and post mortem tenderization. The total amount of each cation was determined in the meat of thirty-two young Herefords at three and thirteen days post mortem along with the amount of each cation in the water extract and in the juice expressed on heating. The same determinations were made on two steers at various times between two hours and thirty days post mortem.

During the aging process sodium and calcium were

continuously released by the muscle proteins, potassium was absorbed after the first twenty-four hours, and magnesium was released during the first twenty-four hours and also between six and thirteen days followed by a decrease in released magnesium.

The total cationic shift was a movement of cations onto the meat proteins. This resulted in an increased charge on the meat proteins allowing greater hydration and improved tenderness. Since calcium is known to cause dehydration of the meat proteins, its release was explained as also having a positive effect on the degree of hydration.

No definite conclusions could be made concerning the relation of these cationic changes to sex or diethylstilbestrol treatment of the animal due to the small number of animals in each group.

The absolute amounts of each cation in the meat, in the water extracts, and in the juice had no significant correlation with tenderness. It was concluded that the importance of cations to hydration and tenderness of meat was not due to the total amount of each cation present but rather to their combined effect and to the movements of these ions during post mortem aging.

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Studies Relating to the Freezing of Sweet Potatoes[a]

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(Manuscript received January 13, 1956)

Up to the present time, canning has been the most commonly used method for processing the sweet potato, *Ipomoea batatas*. It is difficult to preserve the sweet potato by canning and still retain its high quality. This study was undertaken to investigate some of the influences of various cooking methods and freezing on the quality of sweet potatoes. It was also designed to develop, if possible, an improved procedure for the preparation and freezing of sweet potatoes that would result in a superior quality product. Various factors associated with this process were also studied.

Woodroof *(3)* reported that the baking of sweet potatoes prior to freezing gave a product of good flavor, but the process was slow and high temperatures caused sugar to caramelize. He stated further that cooking in water caused losses in flavor, natural sweetness, and color and that the puree became too moist. Sistrunk *et al. (2)* reported a slight loss in sugar, on a dry weight basis, as a result of baking as compared with canning sweet potatoes under 10 pounds pressure. However, it appeared that a certain amount of sugar was converted during processing regardless of method used.

[a] Florida Agricultural Experiment Stations Journal Series, No. 463.

EXPERIMENTAL METHODS

Six varieties and breeding line of sweet potatoes were prepared and frozen after they were cured at 85° F. for approximately 10 days. The varieties included Unit No. 1 Porto Rico, Leland Bunch Porto Rico, Early Port, Goldrush, Easter and Georgia Red.

Each lot of potatoes was divided into 4 sizes according to diameter. Size No. 1 ranged from 1½ to 2 inches; No. 2, from 2 to 2½ inches; No. 3, from 2½ to 3 inches; and No. 4 ranged from 3 to 4 inches.

Both peeled and non-peeled sweet potatoes were frozen. Those frozen with the skins attached were prepared by washing and trimming prior to cooking. Those frozen with the skin removed were peeled by first submerging the potatoes in a 10% boiling lye bath for a period ranging from 8 to 12 minutes. The lye residue and skin fragments were removed with a high velocity water spray rinse. In order to neutralize any lye residue that might remain and also to assist in retaining color, the potatoes were dipped in a 1 to 2% citric acid solution. After this, they were trimmed to remove small ends and any defects that might detract from the appearance of the frozen product.

The potatoes were cooked in preparation for freezing by 5

methods. These methods were (a) baking with dry heat at 350° F., (b) precooking with steam under 10 pounds pressure for 10 minutes and finishing-off in dry heat at 350° F., (c) precooking in free steam for 15 to 30 minutes, depending upon the size of potatoes, followed by finishing-off in dry heat at 350° F., (d) steam under 10 pounds pressure and (e) free live steam without pressure. Except for preliminary work, peeled potatoes were not cooked in dry heat alone.

Firmness was measured by determining the amount of pressure (pounds) required to crush a round core (1½ inches long and 1¼ inches in diameter) taken from the center of the potatoes *(1)*. Samples used for subjective evaluations were frozen after they were cooked to a firmness rating of about 6. Those used to study the effect of cooking time upon the firmness and weight losses were cooked in batches of 6 pounds of fresh potatoes for the different periods of time. When cooked, they were placed in a room at 40° F. and allowed to come to temperature. Then the potatoes were weighed to determine amount of loss as a result of cooking. Each of the 6-pound batches was divided into two equal groups. One-half of each batch was tested immediately for firmness. The other half was frozen and held at 0° F. After *2* weeks, the samples were thawed and the firmness measured to determine the softening effect of freezing.

In preparation for the quality evaluations, frozen potatoes were heated in an oven for 30 to 35 minutes at 350° F. Organoleptic tests of texture and flavor and a scoring for appearance were then made. The taste-panel scores ranged from 1 for lowest to 10 for highest quality. Also, an overall preference rank was given, the lowest number, in this case, indicating highest rating.

RESULTS AND DISCUSSION

Subjective evaluations. In preliminary work an effort was made to bake peeled sweet potatoes with dry heat alone. This did not prove to be practical due to excessive caramelization of the sugars. The outer surface of the potato also became calloused which was objectionable if high quality was to be maintained. As a consequence, only unpeeled sweet potatoes were cooked exclusively with dry heat in preparation for freezing. Potatoes baked and frozen with the skins attached possessed excellent flavor. Since work of other investigators *(3)* indicated that sweet potatoes cooked in boiling water in preparation for freezing were inferior to those cooked with steam because of excessive losses in flavor, natural sweetness, and color, steam rather than water was utilized in this investigation.

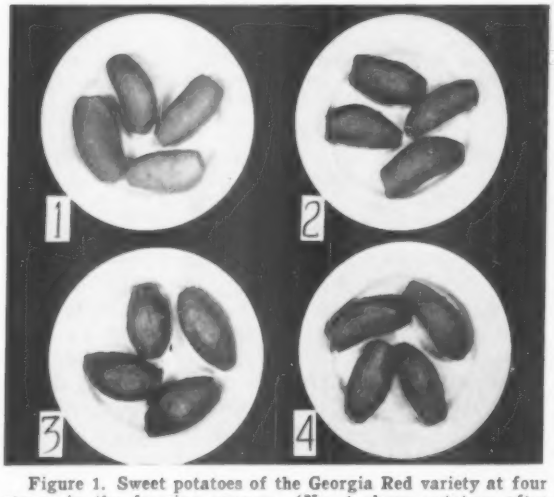

Figure 1. Sweet potatoes of the Georgia Red variety at four stages in the freezing process. (No. 1 shows potatoes after peeling, No. 2 after steam treatment, No. 3 after baking, No. 4 after freezing and heating—ready to serve).

Peeled frozen potatoes of excellent quality were produced when they were partially cooked with steam followed by finishing-off in dry heat at a temperature of 350° F. (Figure 1). When peeled potatoes were cooked with steam under 10 pounds pressure, excessive longitudinal cracking occurred on their surface that detracted from their appearance; whereas, when free live steam was utilized, excessive cracking did not occur.

According to the taste panel, peeled sweet potatoes of the Georgia Red variety precooked with free live steam followed by finishing-off with dry heat prior to freezing were preferred over those of the same variety cooked by any of the other methods (Table 1). Fifty-five percent of the judges preferred those prepared for freezing by partially cooking with free steam followed by dry heat. Twenty-six percent of the judges preferred those cooked with free steam alone and only 19% preferred those prepared by cooking with steam under pressure plus dry heat. Those cooked only with steam under pressure before freezing were least preferred.

TABLE 1

Subjective quality evaluations of frozen peeled sweet potatoes of the Georgia Red variety prepared for freezing by four methods of cooking

Method of cooking	Appearance	Texture	Flavor	Frequency of preference
Free steam plus dry heat	8.0	8.4	8.8	17
Free steam	7.9	8.0	8.3	8
Steam under pressure (10 lbs.) plus dry heat	7.3	8.1	8.6	6
Steam under 10 lbs. pressure	7.1	7.8	7.6	...

Among the varieties and breeding lines tested, the Easter and Georgia Red were preferred (Table 2). The Goldrush variety ranked high but the flavor was graded lower than any of the other varieties by the test panel.

TABLE 2

Average subjective rating of six varieties of sweet potatoes prepared for freezing by baking in dry heat at 350° F.

Variety	Appearance	Texture	Flavor	Preference rank
Easter	9.6	9.2	9.2	1
Georgia Red	9.1	8.4	8.8	2
Goldrush	8.8	7.7	6.9	3
Unit No. 1 Porto Rico	7.3	7.4	7.7	4
Early Port	6.6	8.5	8.2	5
Leland Bunch Porto Rico	6.5	8.6	8.2	6

It was observed that an off-color frequently developed in frozen potatoes when the cooking process was stopped before the firmness reached a point that gave a rating of about 12 pounds. In some cases this discoloration appeared to be similar to that which might occur as a result of cold injury, whereas others possessed an off-color that was more uniform. The extent of the discoloration varied among varieties and was most noticeable in the Leland Bunch Porto Rico and Early Port

varieties. Easter, Georgia Red, and Goldrush retained a good color throughout the freezing and cooking processes and proved to be excellent varieties for freezing.

Effect of cooking upon weight loss. There was a considerable difference in the rate at which the weight loss occurred among potatoes of the various sizes as a result of cooking in preparation for freezing (Figure 2).

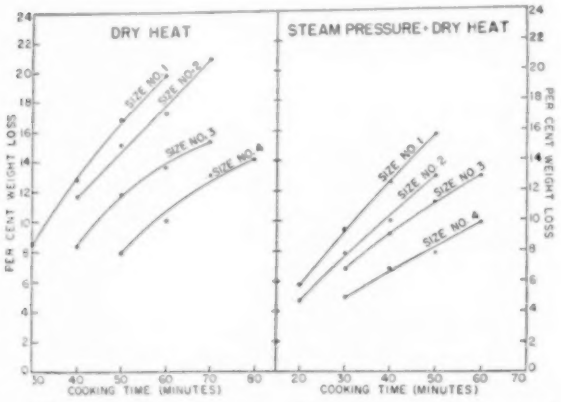

Figure 2. The effect of cooking time upon the percent weight loss of sweet potatoes using four different sizes and two methods of cooking. (Each point represents the mean for four replicates consisting of six pounds potatoes each.)

Smaller potatoes lost weight more rapidly. Similar relationships in weight loss were found when potatoes were cooked with dry heat alone and by cooking with steam under pressure plus dry heat.

Based upon cooking time, the difference in weight loss between potatoes cooked with dry heat and those cooked with steam and dry heat was not large (Figure 2). A different picture was presented when the loss in weight as a result of cooking with dry heat and by a combination of steam plus dry heat was related to firmness rather than cooking time (Figure 3). In this case there was a much higher loss from those cooked with

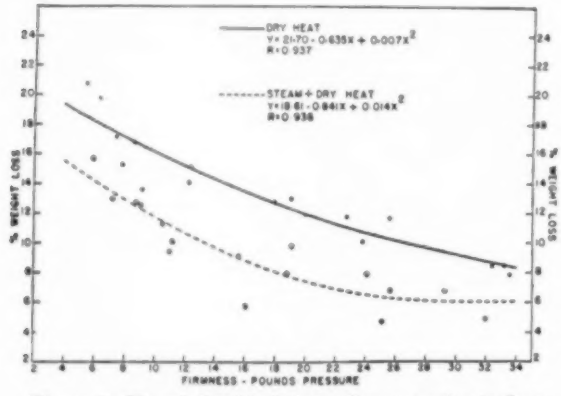

Figure 3. The relationship between firmness prior to freezing and percent weight loss of sweet potatoes cooked by two methods. (Each point represents the mean for four replicates consisting of six pounds potatoes each.)

dry heat than occurred in the ones cooked with steam and dry heat. Potatoes cooked to a firmness of 12 pounds with dry heat lost about 15% of their fresh weight as compared with approximately 10.5% for those cooked with the combination of steam and dry heat. From these results it appears that in the preparation of sweet potatoes for freezing, a considerable increase in the weight of the final product could be realized by partially cooking the potatoes with steam before subjecting them to dry heat.

Effect of cooking on firmness. Larger potatoes required more time to cook to the same degree of firmness than smaller ones (Figure 4). For instance, the cooking time required to bring the firmness of unpeeled potatoes down to 12 pounds differed as much as 10

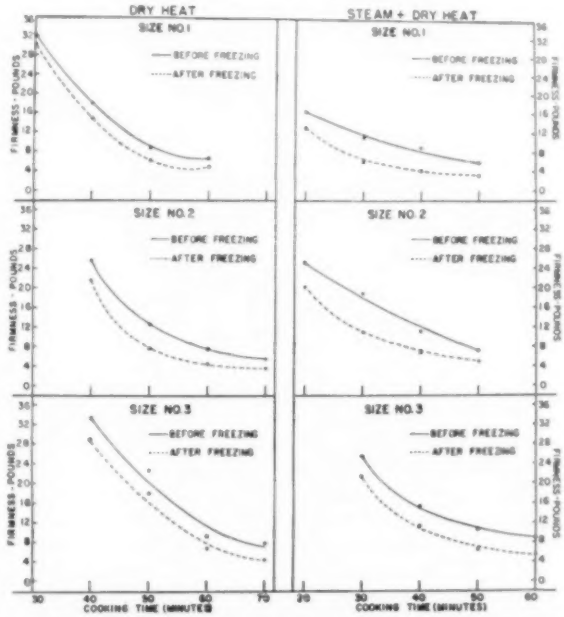

Figure 4. The relationship of cooking time to firmness of three sizes of potatoes before and after freezing when cooked by two methods. (Each joint represents four replicates consisting of three pounds of potatoes each.)

minutes from one size to the next. Potatoes cooked in dry heat alone required approximately 45 minutes for size No. 1 to reach a firmness rating of 12. Size 2 and 3 required approximately 50 and 60 minutes, respectively. In contrast, when potatoes were precooked with steam under pressure for 10 minutes and then transferred to dry heat at 350° F., it required only 30 minutes total time for size No. 1, 40 minutes for 2 and 47 minutes for 3 to reach a firmness rating of 12. This represented a saving of from 10 to 15 minutes as a result of partially cooking the potatoes with steam before baking.

It is evident from the data presented in Figure 4 that sweet potatoes should be graded into size groups before cooking in order to obtain the highest efficiency in their preparation for freezing. If potatoes are to be par-

tially cooked with steam before baking, the larger potatoes may be cut into smaller pieces in order to accelerate the cooking time. However, if they are to be cooked exclusively with dry heat, cutting the potatoes would not appear to be practical due to the excessive caramelization that would occur.

No critical comparisons were made; however, observations seemed to indicate that it required somewhat less time to cook peeled potatoes in preparation for freezing than was necessary for the unpeeled ones. If this hypothesis is correct, one possible explanation might be that the skin forms a sort of insulator which delays heat penetration; whereas, no such obstruction occurs in peeled potatoes.

Effect of freezing and thawing upon firmness. A comparison of the effect of freezing and thawing upon the firmness of four varieties of sweet potatoes is shown in Figure 5. Results indicate that more softening occurred in firmer potatoes up to an original firmness of 20 than in the softer ones. Some difference existed among varieties in their response to freezing and thawing.

When a regression line was fitted to the average of all points of the four varieties (Figure 5), firmness decreased as a result of freezing and thawing at the rate of 0.46 pound for each original unit of firmness. The linear correlation coefficient for the average of these combined values was 0.93, indicating that the softening

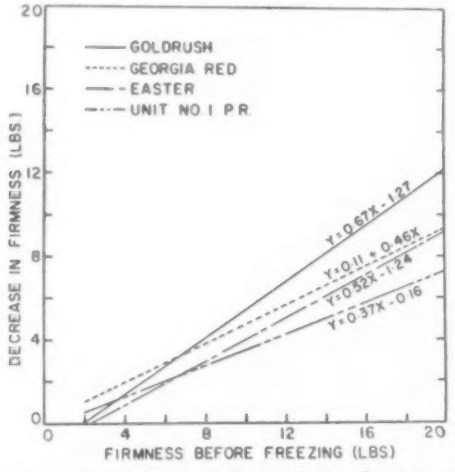

Figure 5. The responses of four varieties of sweet potatoes to freezing and thawing when cooked to different degrees of firmness by baking in dry heat at 350° F.

effect of freezing and thawing was essentially a linear response up to a firmness rating of 20.

The firmness of sweet potatoes decreased approximately 35% as a result of freezing and thawing when they were cooked to a firmness rating of 12 pounds. This lends credence to the possibility that some of the softening affected by cooking might be accomplished by the freezing and thawing effect. Assuming this to be the case, it might be possible to shorten the preparation time, providing the cooking process had progressed far enough for enzymatic deactivation and for flavor development. This would allow for more rapid and efficient operations in the preparation and freezing of sweet potatoes.

SUMMARY AND CONCLUSIONS

A study was undertaken to develop, if possible, a procedure for freezing sweet potatoes that would give a frozen product of superior quality and to investigate some of the factors associated with this process. Sweet potatoes were prepared for freezing by (a) baking with dry heat at 350° F., (b) precooking with steam under 10 pounds pressure for 10 minutes and finishing-off in dry heat at 350° F., (c) precooking in free steam for 15 to 30 minutes, depending upon the size of potatoes, followed by finishing-off in dry heat at 350° F., (d) steam under 10 pounds pressure and (e) free steam. Potatoes were divided into four size-groups according to their diameter in order that the cooking time-firmness relationship could be controlled.

High quality frozen sweet potatoes were produced by all five procedures. However, frozen peeled potatoes prepared for freezing by cooking in free steam plus dry heat at 350° F. were preferred by the largest number of judges.

Among the varieties and breeding lines tested, the Easter and Georgia Red were preferred. The Goldrush variety ranked high but received a lower flavor rating than the other varieties.

In preparing sweet potatoes for freezing they should be graded for size due to the wide range in cooking time required between the large and small potatoes. The time required to cook unpeeled potatoes differed as much as 10 minutes from one size group to the next.

The firmness of sweet potatoes decreased as much as 35% as a result of freezing and thawing. Some difference existed among varieties in their response to freezing and thawing; however, this difference was not large.

Acknowledgment

The authors wish to express their appreciation to Mr. S. A. Harmon of the Georgia Coastal Plains Experiment Station, Tifton, Georgia, for contributing the Easter and Georgia Red variety sweet potatoes for this investigation.

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Knowledge of the Stimulus Variable as an Aid in Discrimination Tests[a, b]

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(Manuscript received February 18, 1956)

TASTE DISCRIMINATION is mediated not only by physiological processes, but also by the psychological processes of judgment and prejudgment. Acuity of taste perception varies with biological make-up, as evidenced in numerous reports on individual and group differences in thresholds and neurological differences in responses to taste stimuli. It is also recognized that taste discrimination can be influenced by a person's knowledge of what he is tasting and his expectations about it. Made specific to the food testing situation, this would mean knowledge of the particular ingredients and composition of the food being examined, plus the parallel knowledge of its advantages, disadvantages, and economics. Where problems of taste discrimination are involved, the face validity of blind testing, i.e., tasting without any knowledge of the identity of the samples other than their codes, has been almost universally accepted in the food industry. However, distinction can be made between knowledge that creates biases in judgment and knowledge that may actually aid judgment, without bias. The latter can be used favorably to increase sensitivity of discrimination.

A common problem of food technology is that of correlating small-scale laboratory panel tests with large-scale consumer tests. The usual difficulty is not that laboratory panels are too sensitive and find differences that consumers cannot appreciate, but more often that small panels cannot find differences that have been decidedly demonstrated by consumer preference. Obvious solutions would be either to select more sensitive individuals for the panel, or simply to increase the number of panel judgments. However, the first may not be possible, nor the second economically judicious where small differences are under examination. A more practical solution may lie in development of more sensitive testing techniques.

One approach to increasing sensitivity of a testing technique would be that of introducing psychological variations within its framework that aid judgment. The feasibility of this approach has been suggested in experiments by Peryam and Swartz *(3)* who implied that discrimination could be aided by consistently presenting the control as either the duplicated or odd sample in the triangle, and concomitantly giving this information to the test subject. Judgment would thus be aided by taking advantage of "familiarity" with the flavor of the control sample. Byer and Abrams *(1)* have shown that discrimination of varying intensities of the odd sample was aided by directing a subject's attention to the direction of difference. This was done by having the subject describe the odd sample in the triangle as of high or low intensity. Pfaffmann *(4)* demonstrated that knowledge of the dimension and direction of difference between the odd sample and the control (sweeter, saltier, etc.) resulted in significantly better discrimination than when no knowledge of the variable was given.

The present study accepted as demonstrated fact that some knowledge of the variable will improve performance in discrimination tests without necessarily introducing bias, and went further to explore the relative effectiveness of various ways of expressing this information. The following questions were considered: (1) Is information about the variable more effective if given in physical terms, or in psychological terms? (2) Is it more effective if only dimension of difference is given or if both dimension and direction along an intensity scale are provided? and (3) What is the effect of inappropriate or misleading information? Our general method of approach was as follows: Discrimination was studied by the triangle method. Four experiments were run, in each of which a different type of change was effected in the odd sample. Eight different types of information about the variable (including no information) were given within the test instructions.

EXPERIMENTAL

Test material. Orange juice was selected as the basic test material and changes in the odd sample were brought about by the addition of sucrose, citric acid, or both. The changes were held within what would be considered the normal range of product variability. These are shown in Table I. The concentration of sucrose shown for Experiment I and that of citric acid and sugar for Experiment IV were based on preliminary testing which showed that differences of this order would result in about 50% correct judgments by trained panel members using the usual (uninstructed) triangle. The concentrations of citric acid in Experiments II and III were chosen so that discrimination would be more difficult. This enabled study of the relative effects of the various instructions on a range of differences.

Perceptual changes corresponding to each of the physical changes were estimated from additional preliminary "two sample" tests in which test subjects, other than those of the study proper, were asked to describe the dimension (quality) and direction in which the variant differed from the control. The instructions given the test subjects in the study proper were selected accordingly. This preliminary work was considered particularly important for Experiment IV where both citric acid and sugar were added. Instructions directed toward increased acidity or sourness appeared more appropriate.

Types of information. Each type of information could be characterized according to (a) whether physical or psychological, (b) whether it pertained only to dimension (flavor quality) or also indicated direction, (c) degree of appropriateness. And each, of course, varied among the four experiments with the physical difference introduced in the odd sample.

Subjects. The same subjects participated in all 4 experiments. They could be classified as panel and non-panel groups. The panel group consisted of 35 members of existing trained taste panels previously established at the Quartermaster Food

[a] This paper reports research undertaken at the Quartermaster Food and Container Institute for the Armed Forces and has been approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

[b] Presented at the Fifteenth Annual Meeting of the Institute of Food Technologists, Columbus, Ohio, June 15, 1955.

and Container Institute for testing various types of products, such as MSG, peanut butter, oleo, milk, orange juice, cocoa and coffee. Their testing experiences were varied: some had served on several panels, some on only one. Their general experience in testing included use of rating scales to judge quality and other properties, and some familiarity with the triangular test. The non-panel group consisted of 35 subjects randomly selected from a larger group of personnel in the Institute. They had relatively little experience in food testing. Some were completely naive but most had participated in food preference tests, using the hedonic scale, about once a week for various lengths of time. They were not familiar with the triangular test.

Test design. A simple balanced design was used in each of the 4 experiments. The testing within an experiment continued over morning and afternoon sessions on two consecutive days. At each of the 4 sessions of an experiment, the 7 instructions (excluding no-information) were randomly assigned to an equal number of panel and non-panel subjects. At each session, subjects took 3 consecutive triangular tests, under the same instruction. This resulted in a total of about 30 judgments for each experiment under each instruction. The same subjects tested in all 4 experiments; however, no one subject received a given instruction in more than one experiment. The no-information tests for all 4 experiments were conducted after all other parts of the 4 experiments had been completed.

Procedure. For the tests where instruction was given, subjects were called to the laboratory in small groups so that all participating at one time would get the same instruction. If a subject was not familiar with the triangle test, the standard directions were given in printed form. Each person was also specifically given, in printed form, the special instruction required by the design. Each triangle consisted of the experimental variant as the odd sample and the control in duplicate. This was, of course, necessary in order to keep the physical arrangement of the test properly oriented to the special instructions.

Three 1-oz. orange juice samples of a triangle were presented simultaneously. The position of the odd sample was different (right, left, middle) in each of the three tests. Multiple codes were used throughout. After each triangle, the subject was told whether or not his choice was correct.

RESULTS AND DISCUSSION

Judgments were tabulated as correct or incorrect and were combined in various ways by type of information to give over-all percentages of correct judgments. Basic data are shown in Table 1 for each experiment. Significance levels were obtained from Tables of the Binomial Probability Distribution *(2)* and are included in the table.

The results shown in Table 1 point up the variability in percent correct judgments that results from including different types of information in the test instructions. The use of some types of information, regardless of whether the actual difference between samples was small or large, resulted in decidedly higher discrimination than the "no-information" situation; others actually depressed percent success below chance level.

To answer the questions originally posed on the relative effectiveness of the various instructions, the data of Table 1 were combined into related categories, and are given in Tables 2, 3 and 4.

The significance of differences between any pair of observed percentages combined across the 4 experiments, was calculated using the critical ratio *(c.r.)*, in which the difference between the two percentages is divided by their combined standard error. To avoid misleading inferences, that could possibly be made through use of multiple significance tests, only those comparisons were made within each of the tables that were orthogonal, i.e., were uncorrelated. The exception was the treatment of data of the lower half of Table 4. Here, however, the consistency of the changes for the four degrees of appropriateness (including no information) across the four independent experiments is so striking that the use of multiple significance tests cannot be considered a serious objection.

Physical vs. psychological. To determine the relative effectiveness of instructions that fell within the categories, *Physical* and *Psychological*, only those were examined that were inferred on the basis of the preliminary studies to correspond to the actual perceptual experience. From Experiment I, for example, where 1.5% sucrose was added to the odd sample, results were used only where the following instructions were given:

TABLE 1

Percent correct judgments from various instructions in Experiments I-IV for all conditions and subjects

Experiment I
(1.5% Sucrose[1] Added to Odd Sample
pH unchanged
Titratable Acidity unchanged)

Information given	% Correct	N	p
1) Has added *sugar*	73.5	30	<0.001
2) Is *sweeter*	63.3	30	<0.001
3) Is less *sour*	56.7	30	0.006
4) Is more *sour*	26.7	30	.....
5) Differ in *sugar* level	60.0	30	<0.01
6) Differ in *sweetness*	63.3	30	<0.001
7) Differ in *sourness*	33.3	30	.....
8) No information	52.0	21	0.05

Experiment II
(0.075% Citric Acid Added to Odd Sample
pH changed from 4.1 to 4.0
Titratable Acidity changed from 0.75 to 0.82)

Information given	% Correct	N	p
1) Has added *citric acid*	48.2	27	0.07
2) Is more *sour*	50.2	30	0.05
3) Is less *sweet*	20.0	30	.....
4) Is more *sweet*	16.7	24	.....
5) Differ in *citric acid* level	50.0	30	0.05
6) Differ in *sourness*	50.0	30	0.05
7) Differ in *sweetness*	13.3	30	.....
8) No information	33.3	21	0.50

Experiment III
(0.125% Citric Acid Added to Odd Sample
pH changed from 4.1 to 4.0
Titratable Acidity changed from 0.75 to 0.85)

Information given	% Correct	N	p
1) Has added *citric acid*	59.3	27	0.004
2) Is more *sour*	62.5	24	0.003
3) Is less *sweet*	59.3	27	0.004
4) Is more *sweet*	30.0	27	.....
5) Differ in *citric acid* level	60.0	30	0.002
6) Differ in *sourness*	63.5	30	<0.001
7) Differ in *sweetness*	40.0	30	.....
8) No information	38.0	21	0.40

Experiment IV
(1.5% Sucrose[1] and 0.25% Citric Acid Added to Odd Sample
pH changed from 4.1 to 3.8
Titratable Acidity changed from 0.75 to 0.95)

Information given	% Correct	N	p
1) Has added *citric acid*	81.5	27	<0.001
2) Is more *sour*	87.8	33	<0.001
3) Is less *sweet*	86.0	36	<0.001
4) Is more *sweet*	23.3	36	.....
5) Differ in *citric acid* level	86.0	36	<0.001
6) Differ in *sourness*	72.1	30	<0.001
7) Differ in *sweetness*	60.5	33	0.001
8) No information	47.6	21	0.10

[1] In excess of original 13.0° Brix.

TABLE 2

Percent correct judgments from appropriate instructions categorized into physical and psychological terms for panel and non-panel groups

Physical Terms

Experiment	Panel and Non-Panel		Panel		Non-Panel	
	% Correct	N	% Correct	N	% Correct	N
I	66.7	60	73.3	30	60.0	30
II	49.0	57	66.7	27	33.3	30
III	59.6	57	63.0	27	56.7	30
IV	76.2	56	81.8	33	70.0	30
	63.3	237	71.8	117	55.0	120

Psychological Terms

Experiment	Panel and Non-Panel		Panel		Non-Panel	
	% Correct	N	% Correct	N	% Correct	N
I	63.3	60	76.6	30	50.0	30
II	50.0	60	43.2	30	56.5	30
III	63.0	54	66.7	27	59.2	27
IV	81.0	63	83.3	30	78.8	33
	64.5	237	67.5	117	61.5	120

Physical *vs.* Psychological, $c.r. = 1.23$, $p = 0.20$.
Physical, Panel *vs.* Non-Panel, $c.r. = 3.0$, $p = 0.003$.
Psychological, Panel *vs.* Non-Panel, $c.r. = 0.98$, $p = 0.30$.

the *Physical* instructions, "Different sample has added sugar," and "Samples differ in sugar level," and the *Psychological* instructions, "Different sample is sweeter," and "Samples differ in sweetness." Results from comparable appropriate instructions were selected from experiments II, III, and IV. These results appear in Column 1 of Table 2 combined for panel and non-panel groups. No significant difference was found between physical and psychological instruction. This fact may have particular bearing on tests for off-flavor where physical or chemical changes are known but where their psychological counterparts cannot always be adequately described.

TABLE 3

Percent correct judgments from appropriate instructions categorized into dimension and dimension plus direction

Experiment	Dimension		Dimension Plus Direction	
	% Correct	N	% Correct	N
I	61.7	60	68.4	60
II	50.0	60	59.2	57
III	61.8	60	60.8	51
IV	72.7	66	85.0	60
	61.8	246	66.2	228

Dimension *vs.* Dimension Plus Direction: $c.r. = 1.00$, $p = 0.30$.

Panel vs. non-panel. Inspection of the data in Column 1 of Table 2 shows that differences in percentages between physical and psychological instruction varied to some degree among the individual experiments. To determine whether this might have been brought about by possible differences in interpretation of either the physical or the psychological terms, based on the subjects' familiarity or non-familiarity with those terms, a further break-down of the data was made according to panel and non-panel groups. This break-down is given in Columns 2 and 3 of Table 2. Where instructions were given in physical terms, the panel was able to discriminate to a significantly higher degree than the non-panel group. Where instructions were psychological, no difference between panel and non-panel discrimination was found. The lowest percent correct judgments occurred in Experiment II and for the non-panel group when instructions were given in physical terms. It was here that the non-panel group first encountered the term "citric acid." Although all percentages for Experiment II were low, because of the small difference in intensity of the odd sample, the possibility nevertheless exists that they were reduced still further owing to the fact that the non-panel group or at least some of its members, were not exactly sure about the term "citric acid" and its connection with the experience of sourness.

This explanation might be tested in a comparable experiment with some relatively unusual substance where we would be certain that only a specifically trained panel would be helped by the name.

It may be inferred that physical and psychological terms are equally effective, but this must obviously be qualified by the statement "provided the subjects are familiar with the terms used."

TABLE 4

Percent correct judgments from instructions categorized on the basis of appropriateness as inferred by the experimenters, a priori (psychological instruction data only)

Dimension

Experiment	Appropriate		Possibly Appropriate		No Information		Inappropriate	
	% Correct	N	% Correct	N	% Correct	N	% Correct	N
I	63.3	30	33.3	30	52.0	21	.....	.....
II	50.0	30	13.3	30	33.3	21	.....	.....
III	63.5	30	40.0	30	38.0	21	.....	.....
IV	72.1	30	60.5	33	47.6	21	.....	.....
	62.5	120	37.4	123	42.7	84		

Dimension and Direction

Experiment	Appropriate		Possibly Appropriate		No Information		Inappropriate	
	% Correct	N	% Correct	N	% Correct	N	% Correct	N
I	63.3	30	56.7	30	52.0	21	26.7	30
II	50.0	30	20.0	30	33.3	21	16.7	24
III	62.5	24	59.3	27	38.0	21	30.0	30
IV	87.8	33	86.0	36	47.6	21	23.3	30
	66.7	117	57.0	123	42.7	84	24.6	114

Dimension, Appropriate *vs.* Possibly Appropriate, $c.r. = 4.2$, $p < 0.001$.
Dimension and Direction, Appropriate *vs.* Possibly Appropriate, $c.r. = 1.57$, $p = 0.12$.
Dimension and Direction, Appropriate *vs.* Inappropriate, $c.r. = 6.8$, $p < 0.001$.
Dimension and Direction, Inappropriate *vs.* No Information: $c.r. = 2.7$, $p = 0.007$.

Dimension vs. dimension plus direction. To determine the effectiveness of giving direction of difference along an intensity scale together with the dimension of difference, rather than dimension alone, the data from the four experiments were recombined as shown in Table 3. Again results from only appropriate instructions were considered; those from questionably appropriate and inappropriate instructions were omitted. For example, from Experiment I only results from the instruction, "Samples differ in sweetness," were summarized under *Dimension;* and only results from the instruction, "Different sample is sweeter," were sum-

marized under *Dimension plus Direction*. The *c. r.* test on combined results shows no significant difference in discrimination. It was contradictory to common sense to find that providing this supposed additional aid did not help performance. Perhaps further scrutiny may determine whether it was due to the particular conditions of this experiment. However, if this is generally true, it should be both useful and comforting to those who do quality control, where it may be impossible to specify direction even though dimension may be known.

Appropriateness of description. The 7 instructions (excluding no-information) may be classified according to how appropriate the information is, as was selectively done in the presentation of data in Tables 2 and 3. For example, the experimenters decided on the basis of preliminary studies that for Experiment I, where sugar alone was added, *Appropriate* should include: "Different sample has added sugar," "Different sample is sweeter," "Samples differ in sugar level," and "Samples differ in sweetness": *Inappropriate* should include "Different sample is more sour;" and *Possibly Appropriate* should include, "Different sample is less sour;" and "Samples differ in sourness." (The third category encompasses the principle that sweetness and sourness in orange juice are not mutually exclusive intensities of the two characteristics.)

It is recognized that the possible ways of providing inappropriate or incorrect information are numerous. For this study only those were chosen which gave the subject some leeway in setting them aside in favor of the true perceptual experience. For example, where sucrose was added, the instruction, "Odd sample is more burnt," was not chosen since this would be obviously incorrect to the subject, while the instruction, "Odd sample is more sour," would at least raise some question in the subject's mind as to possible application.

Data classified according to degrees of appropriateness appear in Table 4 with the no-information data in its logical place on this continuum. Only those from psychological instruction were used for this classification since some of the physical possibilities were missing, such as "Different sample has subtracted or diminished sugar." The *c.r.* tests show some differences between paired percentages. Discrimination was significantly poorer when dimension only was given and where the information, as judged by the experimenters, was only possibly appropriate. Where direction as well as dimensions was given, the slightly lower discrimination from possibly appropriate information did not reach significance. This differential effect would mean, for example, that in the experiment where sugar was added, the questionably appropriate instruction, "Different sample is less sour," giving direction as well as dimension, was more meaningful than the instruction, "Samples differ in sourness," giving dimension only. It stands to reason that fewer subjects succeeded with the latter instruction, since when given the information, "Samples differ in sourness," they might look for the odd sample as the more sour rather than the two duplicates. The data show that discrimination was extremely poor where information was inappropriate. It was, in fact, significantly poorer than where no information at all was given. Percent success was actually depressed below chance level. This means simply that subjects when told, for example, that the sweetened sample was "more sour," would shift to one of the duplicate samples and ignore or overlook the second duplicate. Thus they were "correct" with regard to sample intensity but "wrong" in terms of the triangular test. These results point up the invaluable aid that information about the variable can provide in problems of discrimination. However, at the same time they show that extreme caution must be exercised in selecting information that will in no way contradict the subject's actual experience.

SUMMARY

The relative effectiveness of seven different types of instructions imparting knowledge of the variable in the triangular test was studied. This was done by means of comparisons among the types of instructions and also comparisons with the "no information" situation. The instructions could be classified according to (a) whether physical or psychological, (b) whether they pertained only to dimension (flavor quality) or also indicated direction, (c) degree of appropriateness. The instructions were used in four experiments in each of which a different type of change was effected in the odd sample. An equal number of trained and untrained subjects participated in the study.

Results showed that: (1) Physical and psychological terms were equally effective. However, this might have been dependent upon the subjects' familiarity with the physical terms in order to be able to relate them to his perceptual experience. (2) Including direction of difference in addition to dimension did not improve discrimination. (3) The subjects were guided by the information given them regardless of whether or not it contradicted perceptual experience. This was found over a range of stimulus differences. (4) Information about the variable can be of great help in increasing the sensitivity of discrimination tests but care must be taken that the information is definitely appropriate.

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Sweet Potato Dehydration: Time and Temperature of Storage Related to Organoleptic Evaluations[a]

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(Manuscript received February 2, 1956)

AN INVESTIGATION of the characteristics of raw sweet potato stock for dehydration techniques and treatment of the sweet potato in order to select the raw materials best suited for dehydration and the best preprocessing methods of handling has been underway at the Southern Regional Research Laboratory *(11)*. One phase of the work concerned the actual production of the dehydrated samples and related certain chemical characteristics of both the raw and dehydrated lots to the conditions of storage under which the raw stock was held *(1)*. Samples of a selected number of the freshly dehydrated and stored dehydrated lots—both time and temperature of storage having been varied—were made available for another phase of this investigation which related the palatability of the dehydrated products to the conditions under which the raw materials and the dehydrated products were stored. Previous investigators have related nonenzymatic browning or rather the lack of it with palatability of reconstituted dehydrated sweet potatoes *(7, 9)*, and the effect of processing variables on storage stability *(10)*.

The purpose of this investigation was, therefore, to determine the effects of the conditions of storage of the raw materials and the dehydrated products on the odor, flavor, texture and color evaluations of the dehydrated products as reconstituted and to determine if any relationship existed between these and the chemical characteristics of the same samples as published by Arthur *et al. (1)*.

METHODS

Taste panel. The panel consisted of 19 individuals, 11 males and 8 females, previously selected from a group of 71 volunteers for their acuity at the 1% level *(13)* in detecting small differences in flavor between sweet potato samples according to the method of Girardot, Peryam and Shapiro *(6)*. New members added to the panel were tested in the same way as the original members and were not incorporated into the panel until their scores were demonstrated to be in accord with panel scores by applying the "t" test *(16)*. An average of 35% of those individuals examined were found to possess the desired acuity. The panel's ability to reproduce its judgments at any one session was checked by presenting sets of hidden duplicates among the coded samples to be evaluated. The panel was never aware of when it would be checked and duplicates were coded in a manner similar to the research samples being evaluated so that the relationship of one sample to another at one session was unknown to the judge. A further check on the panel was accomplished by comparing results by the Southern Regional Research Laboratory panel with those of the Western Regional Research Laboratory panel when each panel scored samples within the same series. The panel scores from the Western Laboratory were the averages of judgments by 9 to 11 judges replicated 4 times. The data from the two panels were in satisfactory agreement.

One step in the preparation of the dehydrated dice involved spraying the raw sweet potato cubes with a sulfite solution to prevent discoloration. Much of the sulfite put on the cubes at this stage was lost during drying. However, small quantities, approximately 10-100 p.p.m. remained on the dehydrated product. It was essential to know if this small quantity of sulfite had any influence on the flavor evaluation of the samples. It was found that not only was the panel unable to rank correctly 2 sets of 3 samples each of whipped canned sweet potatoes to which had been added 10, 50 and 100 p.p.m. of SO_2 when these were presented in random order but that in only 2 out of 6 triangle tests (one or 2 samples contained sulfite at levels of 10, 40, 60, or 100 p.p.m.) was the panel able to distinguish between the sulfited samples and the control at the 5% level. It was concluded that the panel was unable to recognize sulfite at these low concentrations and that its presence in less than 100 p.p.m. would not influence their judgments for flavor *(2)*.

Score sheet and its use. Reconstituted dehydrated sweet potatoes were evaluated for odor, flavor, texture, and color using Quartermaster Corps Specifications as a guide *(12)*. Each characteristic of the reconstituted product to be evaluated by the panel was broken down into 6 descriptive terms; final order of terms and actual words used were arrived at with the cooperation of the panel. For example, Figure 1 shows that the "Typical Sweet Odor and Flavor" of the sweet potato were graded in terms of decreasing quality characteristics as follows: *excellent, very good, good, fair, poor,* and *none*.

Subdivision of "texture" was based on Quartermaster Corps Specifications *(12)* which stated that, "after rehydration and cooking, the product shall be soft and tender in texture and shall not be soggy or gummy." Allowance was made by the panel for uncontrollable inequalities among the samples that sometimes resulted in dice that were *firm* rather than *soft and tender* by

PANEL EVALUATION OF RECONSTITUTED DEHYDRATED SWEETPOTATOES

SERIES NO. _____ DATE _____

TEST NO. _____ NAME _____

Typical sweet odor and flavor

Sample Number						
Characteristic	O	F	O	F	O	F
Excellent						
Very good						
Good						
Fair						
Poor						
None						

Comments _____

Undesirable odor

Earthy			
Musty			
Rancid			
Scorched			
Hay-like			
Other			

Undesirable flavor

Old			
Moldy			
Sour			
Bitter			
Sulfite			
Other			

TEXTURE				COLOR			
Sample Number							
Soft and tender				Bright orange			
Firm				Yellow orange			
Mushy				Yellow			
Gummy				Brownish yellow			
Grainy				Brownish orange			
Fibrous				Brown			

Figure 1. Sample score sheet.

[a] Presented in part at the Regional Conclave of the American Chemical Society, New Orleans, Louisiana, December 10-12, 1953.

[b] One of the laboratories of the Southern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

including the term *firm* in the list of texture characteristics and giving it the second position. Although all samples were cooked to the same water level, most of them were *soft and tender* but some were *firm*. *Soggy* was translated into *mushy* and *gummy*. *Grainy* and *fibrous* were added because these characteristics became more noticeable in some of the samples after long storage of the raw materials. The panel then arranged these terms in the order in which they appear in Figure 1 based on their desirableness or capacity to contribute favorably to the palatability of the sample. For instance, the *soft and tender* reconstituted dice were considered most desirable and palatable by the panel whereas the *fibrous* piece was considered undesirable.

Color was likewise subdivided into 6 categories, but here the subdivisions were based on the possible loss of the bright orange color in the raw materials during their storage and processing as well as the browning that might occur in the dehydrated product when it was stored. The necessity for color references became apparent immediately after color evaluation of these products got under way. Available color standards did not orient the panel properly for assessing color of the samples since none of the standards possessed the wet appearance, gloss, and texture of the whipped sample which was being graded. This difficulty was overcome by preparing color references which were commensurate with the changes expected to occur during this investigation *(8)*. The references were made by embedding ground dehydrated sweet potato dice in a suitable plastic such as methyl methacrylate and mounting the hardened discs on a wooden tray with sufficient space between discs for inserting and comparing unknowns.

Judges made use of the score sheet, Figure 1, by placing check marks on the latter corresponding to the intensity of the characteristics which they felt the sample possessed. Check marks were placed either in the vacant space or on the line giving the judge 11 categories into which he might place a sample for each characteristic measured.

Taste panel room. Stainless steel forks were used for sampling and beakers of cool water and cartons for waste samples were supplied. The collapsible table and partitions, painted white, provided semi-private booths, and judgments were made under a red light. With these facilities it was possible to accommodate 8 judges simultaneously. The room was air conditioned and maintained at approximately 75° F.

Preparation and presentation of samples. Approximately 150 to 200 grams of the dehydrated material were reconstituted by adding 3.5 times the weight of the sample of hot water at approximately 140° F. and soaking for 2 hours. The mixture of swollen dice and water contained in a covered white porcelain casserole was then placed on an electric hot plate (1500 W), heated to medium, brought to a boil, and simmered for approximately 45 to 60 minutes. When cooked, the reconstituted material was divided into 2 portions. One portion was whipped with an electrical beater (Hamilton Beach, Model G)* for 10 minutes at speed 7. Whipping was necessary because the judges found it difficult to render a judgment on flavor alone when texture was also present as a variable. Approximately 1 tablespoon of the whipped sample was placed in a 2-inch petri dish and covered immediately. Dishes were kept warm in an air oven heated to 170° F. until the reconstituted materials were evaluated by the panel. The other portion was subdivided and presented in the diced form for texture evaluation. Approximately 10 or 12 dice were placed in one petri dish, covered, and kept warm until tasted. Three to 5 samples were graded at one session. Each sample was coded by letter so that its relationship to any other sample was unknown by the judges.

In a storage study on raw sweet potatoes extending over a period of 7 months, it was desirable for the panel to evaluate samples as soon as possible after dehydration. This excluded the possibility of setting up a planned experiment as recommended by Cochran and Cox *(3)* whereby each sample would be tasted for a selected number of times in the presence of each of the other samples. Satisfactory means for stabilizing the dehydrated samples for long periods of time were not available so that samples for control purposes were not used. Instead the panel compared one sample from each storage temperature at one session, all samples having been withdrawn from storage at the same time.

Routine of tasting used in these investigations. When evaluating the samples, a judge smelled each sample in turn replacing the cover immediately and recording his judgment for odor. In rating the sample for flavor, the judge desiring so first rinsed his mouth with cool water, tasted the first sample and recorded his judgment, rinsed his mouth again with cool water, waited 60 seconds and then tasted the second sample. The routine was then repeated for the remaining samples. Use of the water rinse was left to the discretion of the judge, whereas the time interval between samples was required. The remainder of each of the samples in this series, after odor and flavor had been scored, was used to grade color in a specially arranged booth *(8)*. The judge then received a second set of samples to be evaluated for texture. These were the diced samples and the technique of examination was to introduce several of the dice into the mouth and crush between the tongue and the roof of the mouth. Again, rinsing between samples was optional.

Quantifying the data. To simplify handling the data, the descriptive terms were arbitrarily quantified by assigning numerical values to each term. Since 6 terms were used to describe the various degrees of the characteristics, odor, and flavor, the numbers 1 to 6 were assigned as follows: *excellent* = 6; *very good* = 5; *good* = 4; *fair* = 3; *poor* = 2; and, *none* = 1. Color was similarly quantified, 6 being assigned to "Bright Orange." Panel averages and estimated standard deviations were calculated for each characteristic of each sample judged on one day. The estimated standard deviations of the 3 to 5 samples judged at the same session for 1 characteristic were pooled to calculate a least significant difference, LSD. The estimated standard deviations were adjusted for grouping by applying Sheppard's correction *(5)*.

MATERIALS

The dehydrated samples made available for sensory evaluations were processed at the Southern Regional Research Laboratory *(1)* from 50-pound sublots shipped periodically from the Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana. Storage of the raw sweet potatoes at the Experiment Station was at 50°, 60°, 70°-75° F. for 7 months after curing and at 70°-75° F. for 2 months after curing followed by 2, 3, 4 and 5 months of storage at 60° F. The sublots came from an original lot of approximately 2,000 pounds of the Unit 1 Porto Rico variety sweet potato, grown in West Feliciana Parish, Louisiana, and harvested in October 1952. Variety, climate, fertilization, and time of harvest, were assumed to have had the same degree of influence on all the potatoes used in these experiments. All handling and processing conditions were standardized and their effects on the samples were likewise assumed to be similar. In the dehydrated state the samples were stored under nitrogen in cans at —10°, 75°, and 100° F. and were tested by the panel at 9-, 18-, and 27-week intervals.

RESULTS AND DISCUSSION

The storage intervals and temperatures of the raw and dehydrated sweet potatoes and odor of the dehydrated product prior to reconstituting are outlined in Table 1. The dehydrated products were evaluated as soon after processing as convenient for the panel, although there is some question as to the evaluation being soon enough in the case of the sample cured 10 days at 85° F. Priority was given to those samples most recently processed because panel operations got underway after processing had started. Observations for odor of the dehydrated samples listed in Table 1 show no particular pattern partly because the number of

* Mention of trade products or firms does not imply that they are endorsed or recommended by the U. S. Department of Agriculture over similar products of other firms not mentioned.

samples is too small. Reconstitution data were similar for all samples with the exceptions noted in Table 1. Data for the exceptions are presented, nevertheless, in this and other tables because the information provides

TABLE 1

Storage intervals and temperatures of the raw and dehydrated sweet potatoes and odor of the freshly dehydrated products

Raw sweet potatoes		Dehydrated products[2]	
Storage time in months	Temp. of storage, °F.	Storage prior to evaluation[1]	Odor of dehydrated material before reconstitution
10 days (cured)	85	5 mo. at approx. 75°F.	Slightly rancid
2	50	3 mo. at −10°F.	Off odor
2	60	3 mo. at −10°F.	Good
2	70-75	3 mo. at −10°F.	Good
4	50[3]	None	Not recorded
4	60[3]	None	Not recorded
2 then 2	70-75 then 60	1 mo. at −10°F.	Slightly rancid
4	70-75[3]	None	Not recorded
5	50	1 wk. at 42°F.	Good
5	60	1 wk. at 42°F.	Good
2 then 3	70-75 then 60	1 wk. at 42°F.	Good
5	70-75	1 wk. at 42°F.	Good
6	60	3 days at approx. 75°F.	Strong earthy odor
2 then 4	70-75 then 60	3 days at approx. 75°F.	Strong earthy odor
6	70-75	3 days at approx. 75°F.	Strong earthy odor
7	60	2 wks. at approx. 75°F.	Slightly rancid
2 then 5	70-75 then 60	2 wks. at approx. 75°F.	Slightly rancid

[1] Storage was under nitrogen.

[2] These samples were evaluated while the panel was cooperating on the development of a better formula for reconstituting the dehydrated sweet potato dice. The ratio of water to dice was 4.5:1 and the soaking time was 30 minutes in water at 75°F.

[3] Samples were reconstituted by adding 3.5 times their weight of water at 140°F. and soaking for 2 hours with the exception of those samples referred to in footnote (2).

a legitimate basis for excluding them from later calculations.

Panel averages for odor, flavor, and color, of the reconstituted freshly dehydrated products and LSD's (least significant differences) for each group tested at the same session are outlined in Table 2. LSD's are marked with an asterisk when one or more samples are significantly different from the mean of the rest in the group. Panel evaluations for texture showed that most of the samples fell in the group between *soft and tender* and *firm*. In discussion sessions, the panel agreed that all 4 characteristics measured contributed to the palatability of a sample and selected *fair* to *excellent* as the limits of palatability for "Odor" and "Flavor;" and *mushy* to *soft and tender*, and *yellow* to *bright orange*, as the limits for "Texture" and "Color," respectively. Converted to numbers according to the scheme outlined under "Methods," this meant that a sample with a mean score less than 3.0 for odor or flavor and/or less than 4.0 for color was considered undesirable. Likewise, if the texture was gummy, grainy, or fibrous, the panel members decided that the sample was not edible, i.e., that they did not want to eat it.

In columns 3 and 4, Table 2, it will be noted that the panel consistently ranked the reconstituted dehydrated products made from raw sweet potatoes stored at 50° F. as unpalatable. In the majority of these instances the samples so rated were significantly different from the others judged at the same session. Since the trend persisted throughout the experiment it would appear that evidence has been developed to show that storage of the raw sweet potato at 50° F. has had an undesirable effect on the odor and flavor of the reconstituted dehydrated samples. Color began deteriorating after 4 months but texture appeared not to change during the 5-month storage interval. The reconstituted products made from the dehydrated samples after 5 months of storage of the raw stock at 50° F. were so unpalatable that they were excluded from further analysis by the panel. Excluding those samples not reconstituted according to the formula accepted by the panel, it was found that raw sweet potatoes stored at 60° and 70°-75° F. for as long as 5 months, and at 70°-75° F. for 2 months followed by storage at 60° F. for 2-3 months gave reconstituted dehydrated products with scores within the limits of palatability for odor and flavor. Color began deteriorating after 5 months of storage but texture appeared not to change during that interval.

TABLE 2

Panel evaluation of reconstituted freshly dehydrated sweet potatoes for odor, flavor, and color[1]

Storage conditions of raw sweet potatoes				
Time, months	Temp., °F.	Odor	Flavor	Color
10 days	cured	3.4	2.8	3.9
2	50	3.3	2.6	4.9
2	60	3.6	3.8	4.7
2	70-75	3.9	3.9	4.7
	LSD[2]	0.7	0.5*	0.5
4[4]	50	2.4	2.4	5.0
4[4]	60	2.5	2.3	4.8
2 then 2[3]	70-75 then 60	3.3	3.5	4.6
4[4]	70-75	3.4	2.7	4.9
	LSD	0.6*	0.6*	0.5
5	50	2.3	2.0	4.2
5	60	3.5	3.4	4.7
2 then 3	70-75 then 60	3.4	3.2	4.7
5	70-75	3.9	3.7	4.6
	LSD	1.0*	0.9*	0.5*
6	60	2.8	2.8	4.5
2 then 4	70-75 then 60	3.0	3.3	4.3
6	70-75	3.6	2.9	4.3
	LSD	0.6*	0.6	0.3
7	60	3.6	3.6	4.7
2 then 5	70-75 then 60	3.5	3.9	4.8
	LSD	0.5	0.5	0.5

[1] Each value represents the average of 19 judgments.

[2] Least significant difference (LSD) calculated by substituting the critical value of "t" for the required degrees of freedom at the 5% level in the equation $t = \frac{d}{S.E.}$ and solving for "d." Standard Error (S.E.) was calculated according to L. H. C. Tippett *(14)*.

[3] Not included in LSD because not sampled at same session as the other samples stored for 4 months.

[4] Samples not reconstituted as the others (see Table 1).

Sublots of the freshly dehydrated samples were stored for 9, 18, and 27 weeks at −10°, 75°, and 100° F., as outlined in Table 3. Reconstitution data were similar for all the samples with the few exceptions noted in Table 3. Observations for odors detected immediately after opening the sealed cans of dehydrated dice showed a trend in which an odor of burnt sugar developed more often in samples stored at 100° F. [approximately 15%

TABLE 3

Storage intervals, temperatures, and odors of the dehydrated products

Storage conditions[1]				Dehydrated products[2]	
Raw sweet potatoes		Dehydrated products		Storage before evaluation	Odor of dehydrated dice before reconstitution
Time, months	Temp., °F.	Time, weeks	Temp., °F.		
0 days (fresh)	.....	9	−10	12 weeks at −10°F.	Off odor decidedly objectionable
			75		
			100		
		18[3]	−10	3 days at −10°F.	Stale beany
			75		Stale beany
			100		Stale beany
		27	−10	4 days at 75°F.	Strong rancid
			75		Strong rancid
			100		Strong rancid
10 days (cured)	.....	9	−10	12 weeks at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato
		18[3]	−10	5 days at −10°F.	Sour
			75		Stale beany
			100		Stale beany
		27	−10	3 days at −10°F.	Slightly rancid
			75		Slightly rancid
			100		Burnt sugar
2 months	50°F.	9[4]	−10	11 days at −10°F.	Sweet potato
			75		Beany
			100		Beany
		18	−10	4 days at −10°F.	Rancid
			75		Slightly rancid
			100		Slightly rancid
		27	−10	7 days at −10°F.	Slightly rancid
			75		Rancid
			100		Rancid
4 months	50°F.	9	−10	17 days at −10°F.	Slightly rancid
			75		Sweet potato
			100		Sweet potato
		18	−10	12 days at −10°F.	Slightly rancid
			75		Slightly sour
			100		Sweet potato
		27	−10	8 days at −10°F.	Sweet potato
			75		Slightly rancid
			100		Slightly rancid
5 months	50°F.	18	−10	15 days at −10°F.	Slightly rancid and slightly burnt
			75		Sweet potato and caramel
			100		Sweet potato and slightly burnt
		27[4]	−10	8 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Burnt sugar
6 months	50°F.	9	−10	28 days at −10°F.	Rancid
			75		Slightly rancid
			100		Slightly rancid
2 months	60°F.	9	−10	11 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato
		18	−10	10 days at −10°F.	Rancid
			75		Sweet potato
			100		Sweet potato
		27	−10	6 days at −10°F.	Slightly rancid
			75		Rancid
			100		Rancid
4 months	60°F.	9	−10	18 days at −10°F.	Rancid
			75		Moderately rancid
			100		Slightly rancid
		18	−10	24 days at −10°F.	Slightly rancid
			75		Rancid
			100		Rancid
		27	−10	7 days at −10°F.	Slightly rancid
			75		Slightly rancid
			100		Hay-like
5 months	60°F.	9	−10	2 days at −10°F.	Slightly rancid
			75		Slightly rancid
			100		Slightly rancid
		18	−10	8 days at −10°F.	Slightly rancid
			75		Burnt sugar
			100		Slightly rancid
		27	−10	28 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Slightly rancid
6 months	60°F.	9	−10	28 days at −10°F.	Hay-like
			75		Slightly rancid
			100		Slightly rancid
		18	−10	9 days at −10°F.	Slightly rancid
			75		Sweet potato
			100		Slightly burnt sugar
		27	−10	15 days at 42°F.	Sweet potato
			75		Slightly hay-like
			100		Slightly hay-like
2 months	70°-75°F.	9	−10	18 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato
		18	−10	11 days at −10°F.	Rancid
			75		Slightly rancid
			100		Slightly rancid
		27	−10	12 days at −10°F.	Hay-like
			75		Hay-like
			100		Hay-like
4 months	70°-75°F.	9	−10	25 days at −10°F.	Slightly rancid
			75		Slightly rancid
			100		Rancid
		18	−10	17 days at −10°F.	Slightly rancid
			75		Slightly rancid
			100		Slightly rancid
		27	−10	22 days at −10°F.	Slightly rancid
			75		Sweet potato
			100		Slightly burnt sugar
5 months	70°-75°F.	18	−10	21 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Burnt sugar
		27	−10	22 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato
6 months	70°-75°F.	9	−10	36 days at −10°F.	Hay-like
			75		Hay-like
			100		Hay-like
		18	−10	49 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato
		27	−10	30 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato
2 months and 2 months	70°-75°F. 60°F.	9	−10	24 days at −10°F.	Rancid
			75		Slightly rancid
			100		Sweet potato
		18	−10	16 days at −10°F.	Sweet potato
			75		Hay-like
			100		Hay-like
		27	−10	13 days at −10°F.	Slightly rancid
			75		Sweet potato
			100		Sweet potato
3 months	60°F.	9	−10	3 days at −10°F.	Slightly rancid
			75		Slightly rancid
			100		Slightly rancid
		18	−10	14 days at −10°F.	Slightly rancid
			75		Hay-like
			100		Sweet potato and slightly caramel
		27	−10	28 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato
4 months	60°F.	9	−10	25 days at −10°F.	Slightly rancid
			75		Hay-like
			100		Hay-like
		18	−10	28 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato
		27	−10	16 days at −10°F.	Sweet potato
			75		Sweet potato
			100		Sweet potato

[4] Dice were colored brown. [1] Storage was under nitrogen. [3] These samples were evaluated while the panel was cooperating on the development of a better formula for reconstituting the dehydrated dice. The ratio of water to dice was 4:1 and the soaking time was 30 minutes in water at 75° F. [2] Samples were reconstituted by adding 3.5 times their weight of water at 140° F. and soaking for 2 hours with the exception of those samples referred to in footnote *(2)*. [4] Ratio of water to dice was 3:1; soaking time was 2 hours in water at 140° F.

of the cans as compared to samples stored at 75° and —10° F. (each approximately 2%)]. Further examination of these data showed that a slightly rancid to rancid odor developed in 58 out of 141 or 41% of the dehydrated samples. Twenty-five of the 58 samples had been stored at —10° F. whereas 17 had been stored at 75° F. and 16 at 100° F., respectively. When these observations were compared with judgments obtained from the panel on the same samples, it was found that off odors and flavors were recorded in 67, 63 and 51% of the panel judgments for reconstituted dehydrated products made from raw sweet potatoes that had originally been freshly harvested, cured for 10 days at 85° F., or stored at 50° F. for 2 to 6 months respectively. Off odors and flavors were recorded in 17, 20 and 15% of the panel judgments for reconstituted products made from raw sweet potatoes stored at 60°, 70°-75° F. for 2 to 6 months, and 70°-75° F. for 2 months followed by 60° F. for 2 to 4 months respectively. In addition, the rancid and burnt sugar odors found in the dehydrated materials before reconstituting were no longer in evidence after cooking. When the panel recorded off odors for the reconstituted samples, they were defined as musty or hay-like. Off flavors were described as old, moldy, or sour. Occasionally a sample was scored as having a scorched odor or a rancid flavor but there was no relationship between the odor of the dehydrated material before cooking and the flavor and odor after cooking. It seems that the objectionable odors of the dried material disappear during reconstitution.

Panel evaluations for odor, flavor, and color of the reconstituted stored dehydrated products are outlined in Table 4 and LSD's are listed for each group tested at the same session. Considered from an over-all viewpoint time and temperature of storage of the dehydrated dice under nitrogen had very little effect on odor, flavor, and color of the reconstituted dice as evaluated by the panel. Panel evaluation for texture showed little variation with the majority of judgments for each sample ranging from "soft and tender" to "firm." However, when the temperature of storage of the raw material is considered, it becomes clear that raw sweet potatoes stored at 50° F. produced dehydrated products that were consistently rated undesirable by the panel. This confirms the data shown in Table 2. Neither time nor temperature of storage of the dehydrated products made from raw sweet potatoes stored at 50° F. had any favorable effect on the odor and flavor of the reconstituted samples.

Arthur *et al. (1)* showed by chemical analyses of the raw sweet potatoes stored at the various temperatures that less shrinkage occurred, more sugars were formed, and a significant quantity of the ascorbic acid originally present was lost in the sweet potatoes stored at 50° F. as compared to those stored at 60°, 70-75°, and a combination of 70-75° and 60° F. After processing, the only notable difference among the freshly dehydrated samples was that the product prepared from sweet potatoes stored at 50° F. appeared to contain an increasing quantity of extractable color as the storage time increased, particularly noticeable between the first and second and fourth and fifth months of storage. According to Hendel, Bailey and Taylor *(7)* extractable color measured by their method can be correlated with nonenzymatic browning of various dehydrated vegetables, the rate depending on the specific vegetable. However, in their investigations the limit of palatability for sweet potato was not reached because of the slow browning rate. In the work of Arthur *et al. (1)*, the authors have reported that the sugar content of the raw sweet potatoes stored at 50° F. had increased significantly as compared to other lots of sweet potatoes stored at 60° and 70°-75° F. An increase in sugar content might easily be suspected to lead to an increase in the rate of browning which would give rise to higher extractable color values. Non-enzymatic browning has also been correlated with unpalatability in a number of dehydrated vegetables *(7, 9)*, so it is possible that such browning may account for the unpalatability of the reconstituted dehydrated products made from raw sweet potatoes stored at 50° F.

Similar evidence in support of the poor quality of raw sweet potatoes stored at 50° F. has recently been reported by Cooley, Kushman and Smart *(4)* for six varieties including the Unit I Porto Rico. Conclusions are based on the increased spoilage, weight loss, sprouting and pithiness that occurred in all varieties at 50° F. as compared to 55° and 60° F.

In connection with the effect of storage of raw sweet potatoes in relation to canning, Wayley *(15)* concluded that storage should be favored from the standpoint of palatability because sweetness is intensified and distinctive flavors become more fully developed. It is regrettable that no temperature-time data were presented. However, Wayley's observations are consistent with the data presented here coupled with the chemical analyses on the same products reported by Arthur *et al. (1)*.

SUMMARY AND CONCLUSIONS

A taste panel of 19 judges was selected from a group of 71 persons who submitted to several series of triangular tests to determine their acuity at the 1% level for detecting small differences in flavor between sweet potato samples. The panel size was kept as nearly constant as possible by the addition of replacements selected on the same basis. Approximately 35% of the individuals examined were found to possess the desired acuity.

Quantification of the data by applying a numerical scale provided a satisfactory approach for uncovering the effects of the many variables involved. Data obtained from the panel on freshly dehydrated material agreed with that obtained on subsamples of this material stored under a variety of conditions. Trends in the 2 sets of data—freshly dehydrated versus dehydrated and stored—appeared approximately the same indicating that the judgments obtained were reliable.

Results of these investigations indicate that the storage temperature of the raw sweet potato has a profound effect on the palatability of the reconstituted dehydrated products made therefrom. Raw sweet potatoes stored

TABLE 4

Panel evaluation[1] of the reconstituted dehydrated products which had been stored for 9, 18, and 27 weeks at −10°, 75°, and 100° F.

Storage conditions raw materials	Storage Conditions of Dehydrated Materials									
	Temp. ° F.	Odor			Flavor			Color		
		9 Weeks	18 Weeks	27 Weeks	9 Weeks	18 Weeks	27 Weeks	9 Weeks	18 Weeks	27 Weeks
0 days (fresh)	−10	2.9	2.8[3]	3.3	2.8	2.4[3]	2.8	4.2	3.9[3]	4.3
	75	2.9	2.5[3]	2.9	2.9	2.2[3]	2.6	4.2	3.8[3]	4.3
	100	2.7	2.8[3]	3.0	2.8	2.4[3]	2.8	4.1	3.9[3]	4.2
	LSD[2]	0.5	0.6	0.5	0.6	0.6	0.4	0.3	0.3	0.4
10 days (cured)	−10	3.4	3.5[3]	2.8	3.2	2.9[3]	2.7	4.3	4.3[3]	4.3
	75	4.1	3.4[3]	2.7	3.5	2.9[3]	2.8	4.2	4.3[3]	4.0
	100	3.4	3.7[3]	2.7	3.2	3.0[3]	2.6	4.2	4.4[3]	4.0
	LSD	0.6*	0.5	0.4	0.6	0.4	0.5	0.2	0.2	0.4
50° F. 2 months	−10	3.0	2.9	2.4	2.9	2.7	2.6	5.0	4.4	4.8
	75	3.4	2.7	3.1	2.8	2.8	2.7	4.9	4.5	4.6
	100	2.9	2.6	2.6	3.0	2.5	2.6	4.9	4.5	4.6
	LSD	0.7	0.5	0.5*	0.6	0.5	0.7	0.4	0.6	0.6
4 months	−10	3.2	3.5	3.5	3.3	3.8	3.9	5.0	4.9	4.7
	75	3.0	3.6	3.3	3.3	4.2	3.5	5.1	4.9	4.7
	100	3.3	3.4	3.6	3.3	3.8	3.5	5.0	4.9	4.7
	LSD	0.5	0.6	0.6	0.7	0.6	0.6	0.4	0.2	0.3
5 months	−10		3.1	3.4		3.3	3.3		4.0	4.7
	75		3.3	3.1		3.2	3.3		4.1	4.0
	100		3.2	3.2		3.1	3.3		4.1	3.9
	LSD		0.5	0.6		0.6	0.6		0.7	0.7*
6 months	−10	2.8			2.9			3.8		
	75	2.4			2.8			3.8		
	100	2.3			2.7			3.7		
	LSD	0.7			0.7			0.8		
60° F. 2 months	−10	4.1	3.9	4.1	3.8	3.8	4.4	4.7	5.0	4.8
	75	3.8	3.7	3.7	4.2	3.8	4.1	4.6	4.8	4.8
	100	3.7	3.3	3.4	3.8	3.5	3.6	4.6	4.9	4.6
	LSD	0.6	0.5*	0.7*	0.6	0.5	0.7*	0.4	0.4	0.4
4 months	−10	3.0	3.4	2.7	3.4	3.8	2.8	4.8	4.7	4.5
	75	3.4	3.7	3.1	3.4	3.8	2.9	4.8	4.8	4.4
	100	3.4	3.9	2.7	3.4	3.7	2.8	4.7	4.7	4.4
	LSD	0.5	0.6	0.4*	0.5	0.6	0.6	0.4	0.2	0.4
5 months	−10	3.9	3.6	3.6	4.1	4.2	3.9	5.0	4.6	4.6
	75	3.6	3.7	3.6	4.1	4.0	3.8	5.0	4.6	4.5
	100	3.5	4.1	3.6	4.0	3.8	3.7	5.0	4.7	4.5
	LSD	0.8	0.4*	0.4	0.8	0.7	0.5	0.4	0.3	0.3
6 months	−10	4.1	3.9	3.5	4.0	4.3	3.7	4.6	4.7	4.6
	75	3.6	3.5	3.7	3.9	4.2	3.7	4.6	4.6	4.7
	100	3.6	3.6	3.9	3.5	4.1	3.5	4.6	4.5	4.6
	LSD	0.7	0.5	0.6	0.7	0.4	0.6	0.3	0.2*	0.3
70°-75° F. 2 months	−10	3.9	3.6	3.8	3.9	4.1	4.2	5.0	5.0	4.7
	75	4.2	3.9	3.9	3.9	3.9	4.2	5.0	4.7	4.6
	100	3.8	3.2	4.1	3.7	3.4	4.4	4.8	4.8	4.4
	LSD	0.6	0.6*	0.6	0.8	0.7*	0.6	0.5	0.5	0.3*
4 months	−10	3.3	3.8	3.3	3.4	3.3	3.5	4.8	4.6	4.6
	75	3.6	3.5	3.7	3.7	3.6	3.6	4.8	4.7	4.4
	100	3.2	3.7	3.5	3.6	3.6	3.8	4.8	4.6	4.4
	LSD	0.6	0.7	0.4*	0.7	0.7	0.8	0.6	0.3	0.3
5 months	−10		4.0	3.8		4.1	4.2		4.5	4.5
	75		3.8	3.9		4.2	3.7		4.6	4.6
	100		3.9	3.8		4.1	4.1		4.6	4.6
	LSD		0.5	0.5		0.8	0.5*		0.3	0.2
6 months	−10	3.9	3.7	3.1	3.9	4.0	3.7	4.3	4.3	4.2
	75	3.4	3.4	3.3	3.8	4.0	3.7	4.3	4.4	4.3
	100	3.6	3.9	3.2	3.9	4.0	3.4	4.2	4.3	4.3
	LSD	0.6	0.5*	0.6	0.6	0.5	0.6	0.3	0.2	0.6
70°-75° F. 2 months and 60° F. 2 months	−10	3.6	3.9	4.1	4.2	4.3	4.3	4.9	4.8	4.7
	75	3.6	3.6	3.6	4.1	4.1	4.0	4.8	4.8	4.6
	100	3.6	4.0	4.0	4.2	4.2	4.2	4.8	4.8	4.6
	LSD	0.7	0.6	0.5*	0.7	0.5	0.5	0.6	0.2	0.2
3 months	−10	4.0	3.8	3.8	4.5	3.9	4.2	4.9	4.6	4.4
	75	3.8	3.9	3.5	4.3	3.7	3.9	4.8	4.6	4.6
	100	3.9	3.7	3.4	4.3	3.8	3.7	4.9	4.7	4.6
	LSD	0.7	0.5	0.6	0.7	0.6	0.5*	0.4	0.3	0.3
4 months	−10	3.9	3.5	3.7	4.2	3.5	3.8	4.5	4.7	4.4
	75	4.2	3.8	3.4	3.9	3.5	3.9	4.6	4.6	4.3
	100	3.6	4.1	3.2	3.5	3.5	3.5	4.4	4.5	4.2
	LSD	0.7	0.7	0.5*	0.5*	0.6	0.5	0.3	0.2*	0.4

[1] Each value represents the average of 15-22 judgments, usually 19.

[2] LSD = Least significant difference calculated by substituting the critical value of "t" for the required degrees of freedom at the 5% level in the equation $t = \frac{d}{S.E.}$ and solving for "d." Standard Error (S.E.) was calculated according to L. H. C. Tippett *(15)*.

[3] Samples not reconstituted as others. These samples were evaluated while the panel was cooperating on the development of a better formula for reconstituting the dehydrated sweetpotato dice. The ratio of water to dice was 4.5:1 and the soaking time was 30 minutes in water at 75° F.

at 50° F., did not produce palatable reconstituted dehydrated products. However, reconstituted products made from raw sweet potatoes stored at 60° and 70°-75° F. for 2-5 months were found to be palatable. Of the 2 variables, temperature and time, temperature appeared to exert a greater effect. Texture of the reconstituted dehydrated dice appeared to be least affected by temperature of storage of the raw sweet potato. Color was more affected, followed by odor and flavor which was most affected. Deterioration in all characteristics measured was noticeable in the dehydrated products made from raw sweet potatoes stored more than 5 months regardless of the temperature of storage.

Time and temperature of storage of the dehydrated products had little or no effect on the palatability of the reconstituted dice. Stored dehydrated dice made from raw sweet potatoes stored at 50° F. produced unpalatable reconstituted products. Stored dehydrated dice made from raw sweet potatoes stored at 60° and 70°-75° F. produced palatable reconstituted products. These data confirm earlier results obtained on the freshly dehydrated material.

Acknowledgments

The author acknowledges with gratitude the interest, encouragement, and helpful suggestions of D. R. Peryam, Quartermaster Food and Container Institute, Chicago, Ill., C. D. Evans, Northern Utilization Research Branch, M.-D. Nutting, Western Utilization Research Branch, F. C. Blanck, Research Consultant on Food, Agricultural Research Service, Elsie F. Dochterman and Albert B. Parks, Bureau of Human Nutrition and Home Economics, and J. D. Tallant, Analytical and Physical Section, Southern Regional Research Laboratory.

The results reported here represent the untiring efforts of many of my co-workers without whose faithful cooperation no data would have been forthcoming. The author is indebted specifically to Dr. I. H. Saltz, M.D., R. L. Arceneaux, B. J. Barrett, M. L. Brown, T. D. Doiron, G. L. Drake, J. N. Grant, A. T. Gros, S. R. Hobart, C. H. Haydel, D. C. Heinzelman, E. A. Jensen, National Cottonseed Products Association Fellow, L. Katz, M. H. LeBlanc, Jr., N. V. Lovegren, T. A. McLemore, L. W. Mazzeno, Jr., D. Mitcham, T. J. Newman, R. E. O'Connor, R. W. Planck, J. M. Poynot, R. M. Reinhardt, E. J. Roberts, H. M. Robinson, J. D. Tallant, E. J. Vicknair, P. Von der Haar, T. L. Ward, and D. A. Yeadon, members of the staff of the Southern Regional Research Laboratory.

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The Quality of Smoked Ham as Affected By Adding Antibiotic and Fat to the Diet And Phosphate to the Cure. I. Cooking Losses, Palatability, Separable Fat, and Shear Values

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(Manuscript received February 13, 1956)

PURPOSE OF THE STUDY reported here was to determine the effect on the quality of smoked ham of (1) adding to the diet of pigs an antibiotic, surplus animal fat, and an antibiotic plus surplus animal fat and (2) of adding sodium diphosphate to the brine pickle. The factors studied were cooking losses, cooking rate, palatability of the roasted ham; percent separable fat in the roasted ham; objective shear values.

Also studied but reported elsewhere were objective color measurements *(11)* and moisture, fat, chloride and thiamine contents of the lean uncooked and cooked ham *(15)*.

Review of literature. *Control.* Published reports on hams from animals whose feed and cure were not stated or did not have supplements of antibiotics or fat, or phosphate cure are referred to herein as control hams.

Weir and Dunker *(27)* reported mean shear values of the biceps femoris and semimembranosus muscles of uncooked hams as follows: Tendered hams 5.1 lbs.; ready-to-eat hams 4.9, and long brine-cured hams 6.3 lbs. Cecil and Woodroof *(7)* reported average shear values of center slices of uncooked hams which had been dry-cured for 41 days and smoked for 22 hours as: 30.3 lbs. for biceps femoris muscle, 21.7 for semimembranosus, 23.7 for semitendinosus, and 17.3 lbs. for rectus femoris muscle.

Reports on fresh pork indicate that shearing strength may vary not only because of differences among animals and variation among separate muscles of the carcass, but also because of differences in the position within the muscle itself *(17, 26)*.

Antibiotics. It has been estimated that at least 80% of the pork on the market today is from hogs fed on diets supplemented with antibiotics.

The mechanism by which antibiotics stimulate growth is not definitely known. Current opinion is that the growth effects are in some way related to changes in the microflora of the intestinal tract. At least two factors are involved: "disease level" and "sparing of nutrients" *(1, 2)*.

Aureomycin fed at growth-stimulating levels could not be found in the residue of meat *(2, 24)*. The lowest feeding producing a detectable carry-over in pigs was 200 p.p.m. Even with 1000 p.p.m. the withdrawal of the antibiotic several days prior to slaughter allowed for clearance of the substance from the muscle *(16)*.

Broquist *et al. (6)* found that cooking pork completely destroyed aureomycin. Stokstad *(24)* stated that broiling chicken for 30 minutes completely destroyed Aureomycin. According to these studies, the carryover of Aureomycin should not be a problem in meats which are commonly cooked well done, as are pork and chicken.

Animal Fat. Since the advent of detergents, large amounts of surplus animal fat have accumulated in the U. S. In 1953, the surplus was estimated to be almost a billion pounds *(9)*. By utilizing this surplus fat in animal feeds the amount and cost of feed required for animals to reach market weight would be simultaneously reduced. It is recognized that the increase in fat reported in some studies *(3, 8)* may not be an advantage in pork as it is in beef cattle and in poultry as the consumer demand in pork requires a meaty carcass with a minimum of fat. Sheffy *(22)* stated that the value of surplus animal fats in swine feeds is still in question.

Phosphate Cure. In recent years, certain complex phosphates have been added to meat in an effort to increase desirable texture, uniform color and juiciness. In 1950, Hall *(13)* and in 1952, Brissey *(5)*, were issued patents involving the use of phosphates in the curing of hams.

Möhler and Kiermeier *(18)* reported that the addition of complex phosphates raised the pH of meat solution only slightly. Heat coagulation shifted the pH value of both the phosphate-treated and untreated samples only 0.3 pH units toward the alkaline side *(19)*. Smoking offset the rise in pH due to coagulation. The addition of salt resulted in a lowering of the pH of the meat by 0.2 to 0.3 units.

The same workers *(20)* tested the effects of phosphates on the swelling of protein. Because the pH of prepared meat is more neutral than its greatest protein fraction, myosin, swelling is already minimized. Möhler and Kiermeier *(18)* believed that the pH changes owing to phosphate addition were too small to make any great difference and that the customary salt addition cancelled out true swelling. Lowered consistency of prepared meats to which phosphates were added was explained as an alteration of the forces holding the structure of the protein together *(21)*.

Wilson *(29)* found that adding phosphates to the pickle did not affect yield. Phosphate treated hams, however, appeared to be firmer and to have less free moisture than did the controls. No conspicuous differences were found by the taste panel in odor, flavor, or tenderness. In overall palatability the panel preferred the hams containing sodium hexametaphosphate followed in order by sodium tripolyphosphate, the control and disodium phosphate. The scores on the visual

color were in the same order except the last two were reversed.

Wilson *(29)* reported that the addition of phosphates to a comminuted product produced no observable benefit in color fixation, in rate of fading, or in taste panel evaluation of a commercial bologna product, treated or untreated. Frank *(12)* reported that an untrained taste panel thought there was better retention of color in meat of frankfurters to which phosphate had been added. Brissey *(5)* reported that disodium phosphate cure substantially improved resistance to discoloration and improved appearance and flavor.

EXPERIMENTAL

History of the hams. The hams used in this study were obtained from the Department of Animal Husbandry,[a] Cornell University, as part of a cooperative project on the effects of adding Aurofac and surplus fat to rations on growth, feeding efficiency and carcass quality of pigs, as well as on quality and composition of smoked and cured hams. The effect of the addition of disodium phosphate to the cure on the composition and quality of smoked hams was also studied.

Hogs. A total of 62 hams was obtained from 31 hogs, representing 6 litters. One pig died from an unknown cause during the feeding experiment. The hogs were all Yorkshire breed.

Rations. All of the pigs were weaned when 8 weeks old, and were fed and handled in the same manner prior to being placed on experiment at 65 days of age. They received the same basic ration consisting of corn, soybean oil meal, meat scraps, salt, and B vitamins. Four lots of 8 pigs each were assigned different treatments such that each litter was represented on every treatment. Lot 1 received a control diet, Lot 2 supplementation with 0.5% Aurofac, Lot 3 supplementation with 3% fat,[b] and Lot 4 supplementation with 0.5% Aurofac plus 3% fat. This amount of Aurofac contributed 9 mg. chlortetracycline formerly referred to as Aureomycin and 9 mcg. of vitamin B_{12} per pound of feed.

Slaughter and preparation for curing. The hogs were slaughtered when they reached approximately 200 lbs. in weight. The hams were wrapped with skin intact in aluminum foil, frozen, and stored at 0° F. until one-half of the total number had been accumulated. Thus all the hams were cured and smoked in 2 lots, thereby minimizing variability arising from differences in curing and smoking conditions. Just prior to curing, the hams were thawed in their original wrappings in a cooler held at 38° to 40° F.

Curing. A curing pickle was prepared from a commercial curing mixture[c] consisting primarily of salt, sugar, nitrate and nitrite. The pickle was boiled, cooled to 40° F., and adjusted to a 70° salometer reading. For the phosphate cure 0.5 lb. of disodium phosphate was added for each gallon of pickle.

Curing pickle equivalent to 10% of green ham weight was artery pumped into the hams. Three-eighths ounce of dry cover cure per pound of ham was then applied to the outside surface, and 7 days later an identical application of dry cure was made. After 14 days of curing at 3.3-4.4° C. (38-40° F.), the hams were soaked in tap water at 10-15° C. (50-60° F.) for 30 minutes and then placed shank down in stockinette bags in preparation for smoking.

Smoking. Hams were smoked at an estimated temperature of 48.8-54.4° C. (120-130° F.) until a mahogany color was obtained, about 16 hours. The hams were then removed and stored at 3.3-4.4° C. (38-40° F.) until they could be tested, which began the following day.

[a] The feeding of the hogs was directed by Professor B. E. Sheffy. Curing, smoking and trimming of the hams were done by Professor H. D. Naumann.

[b] Dar-Sta-Fat supplied by R. E. Crohan, Darling and Company.

[c] Griffith's Modern Ham Pickle.

Sampling of the uncooked ham and preparation for roasting. Each ham was sampled for objective shear, color and chemical determinations and then trimmed for roasting. A slice 1½-inch thick was removed from the anterior portion of the ham and discarded. A portion was removed for chemical analyses immediately posterior and parallel to the aitch bone. A slice 1-inch thick anterior to the preceding cut was removed for shear tests. Anterior to this, a slice 1-inch thick was removed for objective color determination *(11)*. The shank was removed through the stifle joint and discarded. The portion of the hams remaining for roasting weighed approximately 10 pounds.

Roasting. Four hams were roasted and sampled each cooking day. The hams were placed on racks ½-inch high in uncovered shallow aluminum pans 10½ inches in diameter and 2½ inches deep. A thermocouple and a thermometer were inserted in the chunky piece of ham. The thermocouple was attached to an electronic recording potentiometer. The hams were roasted in a well-insulated electric test oven[d] at 148.8° C. (300° F.) to an internal temperature of 76.6° C. (170° F.).

Each roast was allowed to cool to 140° F. before it was weighed and sampled.

A cooking record was kept: losses in weight, cooking drip exclusive of fat, fat drip, and evaporation, and cooking time and rate.

Sampling of the cooked ham. *Shear Force.* The skin on each ham was removed. A 1-inch slice was cut from the larger end of each ham and laid to one side. A 1-inch thick slice for shear determinations was removed. A ¼-inch slice for objective color readings was then removed *(11)*.

Palatability. After removing samples for color and shear determinations, a layer about ⅛-inch thick was removed from the outer surface of the top layer of fat and laid to one side. A second layer of fat of approximately ⅛-inch thickness was removed near the *biceps femoris* muscle and cut into samples for flavor scores. The *biceps femoris* muscle was then stripped out and trimmed of any separable fat or gristle. The muscle was sliced on a hand rotary meat slicer to a thickness of about 1/16-inch. Slices were numbered and rotated each week with judges progressing through the first to tenth slices in 10 weeks. One-inch squares for the "chew" tests were also removed from the slices.

Shear force determinations on uncooked and cooked hams. Four 1-inch cores were cut from the cooked ham slice and 2 cores were cut from the raw ham slice after both had reached room temperature. One shear only was made on each core of meat using the Warner Bratzler shear apparatus.

Separation of roasted ham into component parts. A gross separation of the separable fat, bone and lean was made of the remaining portion of ham after samples had been removed for shear, color and palatability testing.

Palatability scoring. Four ham samples, "chew" squares, and fat samples were scored at room temperature each cooking day. The taste panel consisted of 10 faculty members from the Animal Husbandry Department, Hotel School, School of Nutrition, Institutional Management and Food and Nutrition Departments. A 10-point scale was used to evaluate the color acceptability, aroma with sniffing, flavor, juiciness, saltiness acceptability, tenderness of lean meat, and flavor of fat. The Lowe "chew" test *(14)* was used for further evaluation of tenderness.

Statistical design and treatment.[e] The experiment was planned in a completely randomized design, with 8 pigs randomly selected for each of the 4 diet treatments. A split plot technique was superimposed on the basic design by randomly selecting one ham from each pig for the phosphate cure treatment and the other ham for the control cure. Analysis of variance according to Snedecor *(23)* was applied to the data. Missing data for the 2 hams from the pig which died were calculated according to Yates *(30)*.

Correlation coefficients were made across treatments.

[d] Despatch oven.

[e] The statistical design and the treatment were planned by Professor C. R. Henderson.

TABLE 1
Mean values for cooking data of roast hams

Treatment		Wt. of ham		Weight Loss	Drip loss exclusive of fat	Fat loss	Evaporation loss	Roasting time		Per cent separable fat in cooked ham
Diet	Cure	Uncooked	Cooked					Total	Per lb.	
		gm.	*gm.*	*%*	*%*	*%*	*%*	*min.*	*min.*	*%*
Basal	Control	4486	3406	24.1	9.9	7.7	14.9	254	26	31.0
	PO_4	4354	3315	23.8	9.9	8.7	13.6	238	25	32.0
Antibiotic supplement	Control	4347	3448	20.8	9.0	6.6	11.7	245	26	29.0
	PO_4	4537	3616	19.7	7.8	6.5	12.2	256	26	29.0
Fat supplement	Control	4350	3447	20.9	8.6	7.0	12.3	248	26	28.0
	PO_4	4213	3362	20.4	9.0	8.3	10.9	245	25	31.0
Antibiotic and fat supplement	Control	4305	3384	21.2	8.9	6.4	11.4	258	27	30.0
	PO_4	4329	3354	19.4	8.5	6.6	13.2	248	26	30.0

RESULTS AND DISCUSSION

Significant differences were observed among pigs within diets in (a) all cooking losses except fat loss, (b) cooking time per pound, (c) percent separable fat in cooked roasts, (d) color acceptability, (e) aroma, (f) flavor of lean, (g) saltiness acceptability, (h) tenderness by palatability and by "chew" and (i) shear force in uncooked ham (Table 2). These differences among hams from pigs within diets may have been sufficient to obscure any small differences that might otherwise have occurred among diets.

Fenton *et al. (10)* reported marked differences among beef animals of the same breed, grade and sex. Westerman *et al. (28)* also reported variation among beef animals.

Cooking. *Cooking Losses.* Experimental means for losses during cooking of the 62 center ham roasts were 21.5% weight loss, 9.0% cooking drip exclusive of fat, 7.2% fat loss and 12.5% evaporation loss (Table 1). None of the differences in cooking losses could be attributed to either diet or to cure (Table 2).

Cooking Time. The experimental mean for cooking time was 26 minutes per pound of meat. The differences in cooking time were not found to be related to either the diet or to the cure.

No relationship between the cooking rate curves and treatments were discernible. Typical cooking rates are given in Figures 1, 2, 3, and 4.

Percent separable fat in cooked roast. The experimental mean for percent separable fat in the cooked center cut hams was 30 (Table 1). No significant differences in the percent separable fat could be ascribed to either the diets or to the cures although Sheffy [1] found that the percent of fat to lean was higher in carcasses

[1] Personal communication from Professor B. E. Sheffy, Animal Husbandry Department, Cornell University.

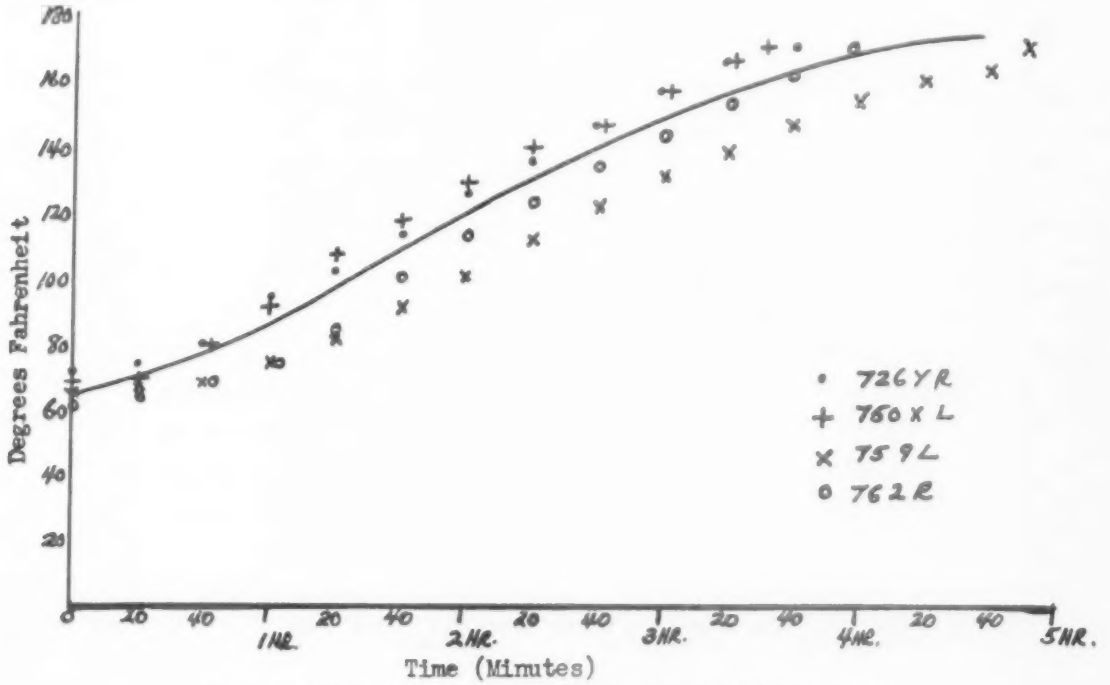

Figure 1. Cooking rates of four control-cured hams from pigs fed a basal diet.

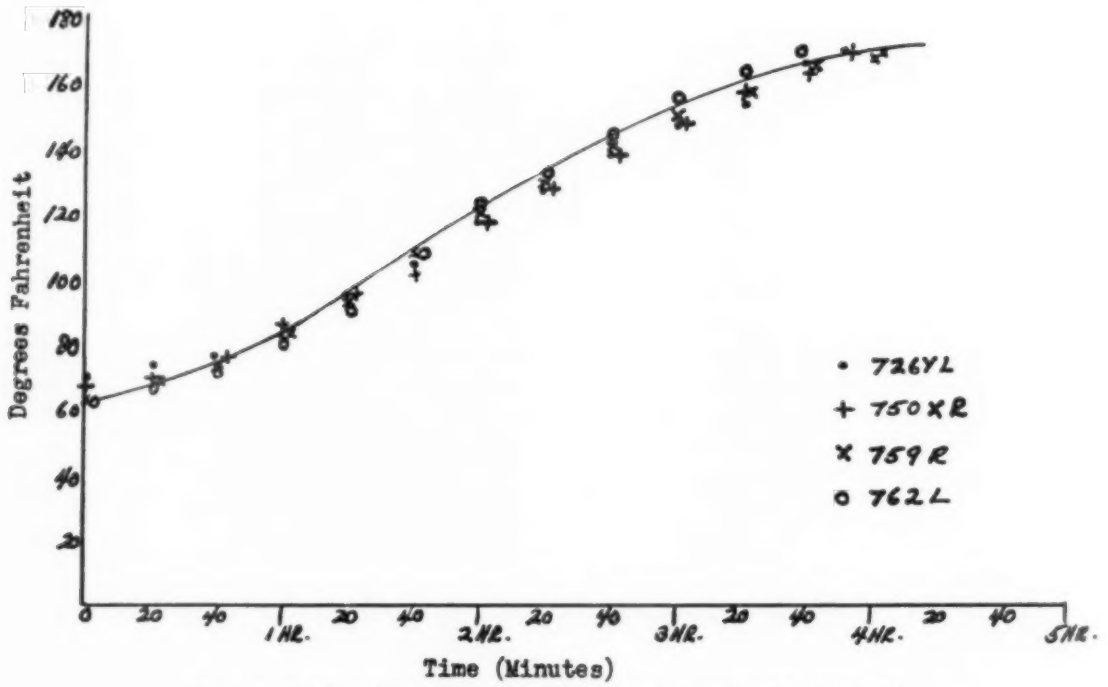

Figure 2. Cooking rates of four phosphate-cured hams from pigs fed a basal diet.

of pigs fed on the fat-supplemented diets, although there was not much difference in the live weights of the pigs.

Organoleptic ratings. *Palatability.* The means for each of the palatability factors were between 7 *(good)* and 8 *(very good)*.

Color Acceptability. The experimental mean for color acceptability scores was 7.5 (Table 3). There were no significant differences in color acceptability scores owing to diet.

There were significant differences at the 5% level

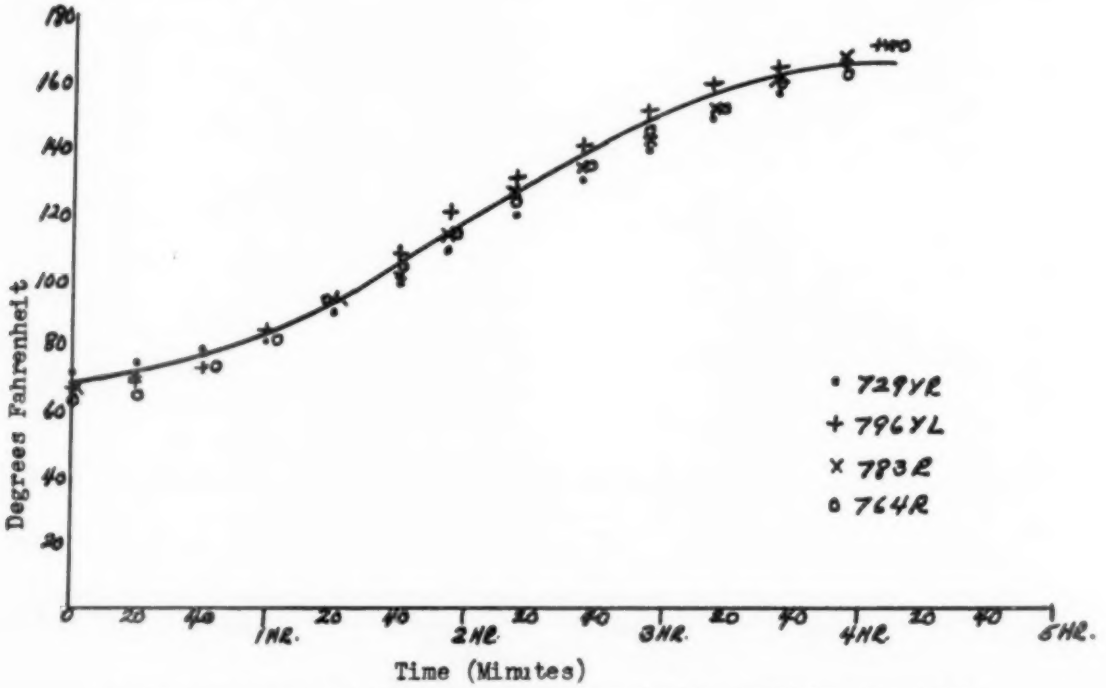

Figure 3. Cooking rates of four control-cured hams from pigs fed an antibiotic-supplemented diet.

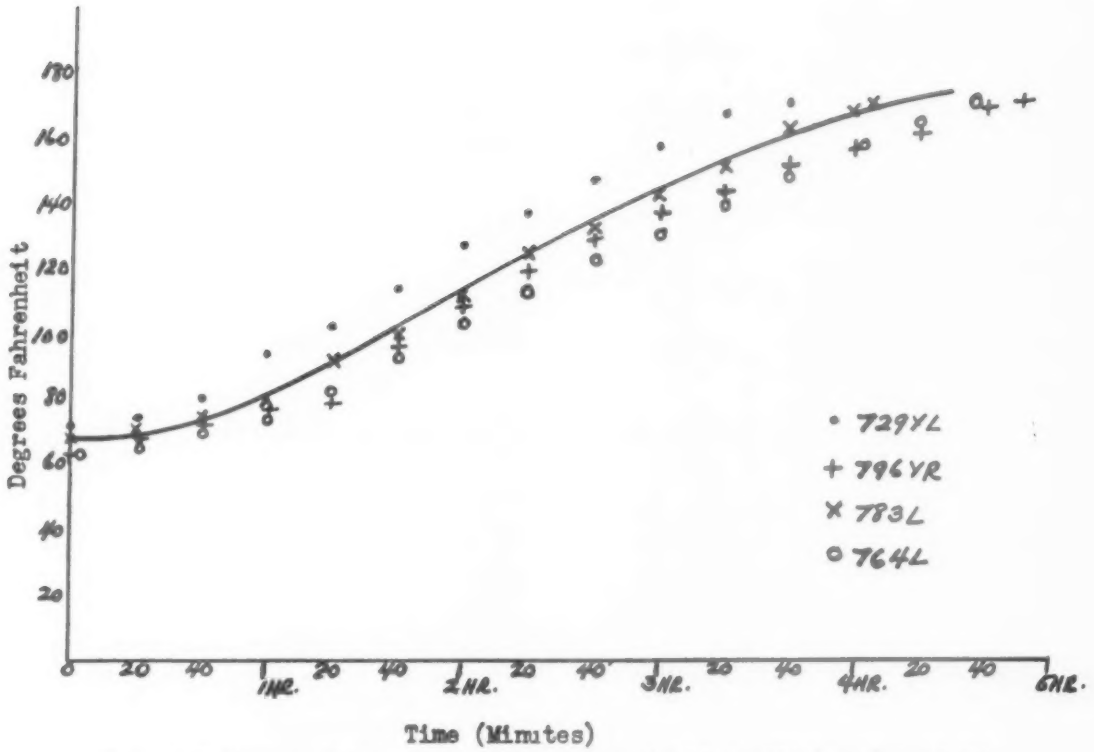

Figure 4. Cooking rates of four phosphate-cured hams from pigs fed an antibiotic-supplemented diet.

owing to method of cure (Table 4). These results are similar to those of Frank *(12)* who found that the palatability panel could pick up color differences in control and phosphate-treated frankfurters. The phosphate-cured hams received slightly higher scores than the control in all diets except the fat-supplemented diet in which the difference was only 0.1 point.

Aroma. The experimental mean of scores for aroma with sniffing was 7.4 (Table 3).

A significant difference at the 1% level owing to diets of the pigs occurred. The rank in order of choice was: ham from pigs on a basal diet, basal plus antibiotic, basal plus fat, and lastly basal plus antibiotic plus fat.

Although a significant difference in aroma owing to curing method was observed the mean score for phosphate-cured samples was only 0.15 units higher than that for control samples.

Flavor of Lean. The experimental mean for flavor scores of lean meat was 7.4 (Table 3).

Differences owing to diet were significant at the 5% level (Table 4). The order was the same as that for aroma.

Curing with a phosphate pickle was not found to affect the flavor of lean meat.

Flavor of Fat. The experimental mean for fat flavor scores was 7.5 (Table 3). No significant differences owing to either diet or cure, or to variation among pigs within diets were observed.

Juiciness. The experimental mean for juiciness scores was 7.2 (Table 3). No significant differences owing to the diet, to the cure, or to variability among pigs within the same diet were observed (Table 4). These results are similar to those of Frank *(12)* who reported no difference in juiciness of control frankfurters and those treated with phosphate salts.

Saltiness Acceptability. The experimental mean of scores for acceptability of saltiness was 7.8 (Table 3).

TABLE 2

Mean squares and significance of cooking data

Variables	df	Per cent losses				Cooking time per pound	Per cent separable fat in cooked roast
		Weight loss	Fat loss	Drip loss exclusive of fat	Evaporation loss		
Diets	3	45.9264	11.2265	6.9158	22.3394	6.38	19.9974
Pigs within diets	27	19.1541[1]	5.7015	5.3752[1]	13.4395[1]	12.80[1]	29.5656[2]
Cures	1	1.9635	6.0454	1.4884	0.3192	3.06	10.5788
Diets x cures	3	2.7484	1.8194	1.9540	7.8317	2.85	9.1804
Error B.	27	8.2674	5.2880	2.3040	6.2254	5.46	11.0675

[1] Significant—5 per cent level.
[2] Significant—1 per cent level.

TABLE 3

Mean values for palatability scores[1]

Diet	Cure	Scores							
		Color acceptability	Aroma with sniffing	Flavor		Juiciness	Saltiness acceptability	Tenderness	No. of "chews"
				Lean	Fat				
Basal	Control	7.5	7.8	7.5	7.7	7.5	7.4	7.5	64.6
	PO_4	7.7	7.8	7.6	7.5	7.2	7.4	7.6	68.8
Antibiotic supplement	Control	7.4	7.3	7.5	7.5	7.3	7.1	7.6	72.6
	PO_4	7.8	7.6	7.5	7.5	7.3	7.4	7.7	71.6
Fat supplement	Control	7.6	7.3	7.2	7.5	7.5	7.2	7.4	72.9
	PO_4	7.5	7.4	7.5	7.5	6.9	7.4	7.4	70.5
Antibiotic and fat supplement	Control	7.2	7.0	7.1	7.2	7.1	7.1	7.5	75.9
	PO_4	7.4	7.2	7.1	7.4	7.0	7.2	7.6	73.6

[1] Maximum possible score was 10.

TABLE 4

Mean squares and significance of palatability scores for baked hams

Variables	df	Color acceptability	Aroma with sniffing	Flavor		Juiciness	Saltiness acceptability	Tenderness	No. of "chews"
				Lean	Fat				
Diets	3	.3739	1.0896[2]	.3408[1]	.2071	.2038	.1816	.0963	193.0803[1]
Pigs within diets	27	.1801[2]	.1437[2]	.1674[2]	.0952	.3783	.1232[1]	.1469[1]	63.4885[2]
Cures	1	.2717[1]	.3306[1]	.1323	.0012	1.3689	.3053[1]	.0848	1.6098
Diets x cures	3	.2080[1]	.0746	.0829	.0620	.2887	.0528	.0203	36.9629
Error B	27	.0569	.558	.0625	.0764	.3264	.0589	.0716	23.3060

[1] Significant—5 per cent level.
[2] Significant—1 per cent level.

No significant differences owing to the diet were found (Table 4).

Although differences in saltiness scores owing to cure were statistically significant at the 5% level, phosphate-cured samples had a mean score only 0.15 units higher than control samples.

Tenderness. The experimental mean for tenderness scores was 7.5 (Table 3). No differences owing to either diet or to cure were found to be significant (Table 4).

Chew. The experimental mean for number of "chews" was 71.4 (Table 3).

A statistically significant difference in "chew" values at the 5% level owing to diet was found (Table 4), but the numerical difference was small, 0.10%. Phosphate curing did not significantly affect the "chew" values (Table 4).

Throughout the course of this study, judges reported similarity in palatability factors of the 4 ham samples tasted each cooking day, stating that they were all very good. Obtaining statistically significant differences in color acceptability, aroma, flavor of the lean, saltiness acceptability, and "chew" scores owing to diets or to cures was not expected. As stated previously, numerical differences were small.

Shear force values. The experimental mean shear force values for the 2 cores from the uncooked semitendinosus muscles were 25.4 pounds, and for the 3 muscles from a different position of the cooked ham (see sampling) were 13.7. Shear values for the roasted ham were: 15.8 lbs. for biceps femoris, 13.4 lbs. for the semimembranosus, 10.2 lbs. for the semitendinosus, and 11.8 lbs. for the vastus lateralis muscle (Table 5).

No significant differences in the shear force values of either the uncooked or cooked ham owing to diet or to cure were observed (Table 6). The significant variation in shear force values between animals in the same diet evident in the uncooked meat was apparently obliterated by cooking.

TABLE 5

Means for shear force values of smoked hams

Treatment		Shear force values	
Diet	Cure	Uncooked	Cooked
Basal	Control	26.7	14.1
	PO_4	24.0	14.7
Antibiotic supplement	Control	25.5	14.3
	PO_4	24.1	12.9
Fat supplement	Control	26.1	13.7
	PO_4	24.2	13.6
Antibiotic and fat supplement	Control	25.7	12.3
	PO_4	26.4	13.7

TABLE 6

Mean squares and significance of shear force values for smoked hams

Variables	df	Shear force values	
		Uncooked	Cooked
Diets	3	3.34	4.70
Pigs within diets	27	23.50[1]	5.54
Cures	1	2.44	0.01
Diets x cures	3	7.14	5.42
Error B	27	9.43	3.19

[1] Significant—5 per cent level.

Correlations. None of the correlations made were significant (Table 7). Since numerical differences between treatments were small, significant correlations could probably not be expected.

SUMMARY

A study was made of the effect of adding an antibiotic and/or animal fat to the diet, and disodium phos-

TABLE 7
Correlation coefficients among qualities [1]

Qualities tested for correlation	r values
Palatability tenderness vs. "chews"	−.15
Palatability tenderness vs. shear values	−.18
Palatability tenderness vs. fat	+.20
Palatability juiciness vs. fat	−.37
Palatability juiciness vs. moisture	+.19
Cooking time vs. fat content (uncooked)	+.04
Cooking time vs. fat to lean ratio in cooked ham	−.19
Fat content of cooked vs. fat to lean ratio in cooked hams	−.20

[1] Correlation calculations were made across treatments.

phate to the cure on the cooking losses, cooking rate, palatability, "chew" values, shear values and percent separable fat of 62 smoked center ham roasts.

Hams, weighing approximately 10 lbs., were roasted to an internal temperature of 76.6° C. (170° F.) in a test oven at a temperature of 148.8° C. (300° F.).

Diet. Statistically significant differences owing to the diets of the pigs were found for: aroma, flavor and "chew" scores. In aroma and flavor hams from pigs fed a basal diet received the highest mean scores, followed by those fed an antibiotic-supplemented diet, a fat-supplemented diet, and lastly an antibiotic-plus-fat-supplemented diet. The lowest number of "chews" was given to hams from pigs fed a basal diet and the highest number to hams from those on an antibiotic plus-fat-supplemented diet. Since the differences were small it is doubtful that any of the differences have any practical significance.

Numerous significant differences in the smoked hams owing to individual variation among pigs within diets may have obscured small differences that might otherwise have occurred among diets. Differences among pigs were found for all factors except fat loss, flavor of fat and juiciness scores.

Cure. Although the phosphate-cured hams received significantly higher scores for color acceptability, aroma, and saltiness acceptability, mean differences were small.

Under the conditions of this experiment neither the diet nor the cure resulted in appreciable differences in the qualities of the smoked hams. Even in the qualities which statistics show were affected, differences were so small that not much inference can be drawn from them. The results indicate that present practices of feeding pigs diets supplemented similarly to those used in this study and giving a phosphate cure are not lowering the quality of the hams.

Acknowledgments

The authors are greatly indebted to Professors B. E. Sheffy, H. D. Naumann, and G. H. Wellington of the faculty of the Animal Husbandry Department of Cornell University without whose assistance this study would not have been possible.

They are also grateful to Professor C. R. Henderson of the same department who planned the statistical design and gave advice on the statistical treatment.

The interest of the taste panel was gratifying. Members were Dr. W. L. Clark, Dr. Faith Fenton, Dr. Ruth Lutz, Dr. Nell Mondy, Miss Aimee Moore, Dr. H. D. Naumann, Dr. B. E. Sheffy, Dr. J. J. Wanderstock, Dr. G. H. Wellington and Dr. H. H. Williams.

The technical assistance of Jean Chen Lin was greatly appreciated.

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The Quality of Smoked Ham as Affected By Adding Antibiotic and Fat to the Diet And Phosphate to the Cure II. Objective Color[a]

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(Manuscript received February 13, 1956)

One of the purposes of curing meat is to fix the color of the meat through the formation of relatively stable compounds from the myoglobin and hemoglobin. According to Haldane *(6)* the process of reduction of nitrate present in the brine to nitrite is normally accomplished by bacterial action. Kerr *et al. (10)* stated that the source of the nitrate-reducing organisms has never been definitely determined but probably is varied. One source may be the interior of the meat. The question of the sterility of meat is controversial. Schweinburg *et al. (17)* reported that the organs of healthy experimental animals including rats, guinea pigs, and hamsters were sterile, and that the blood from vena cava, bile and urine of normal dogs and rabbits was also sterile, but that most of the tissues of healthy dogs, and, rabbits to a lesser degree, harbor clostridia. Jensen and Hess *(9)* in a review of the literature on antemortem and postmortem infections of living animals and tissues of healthy animals reported that much evidence was available to support the theory that bacteria are present in the tissues of healthy animals. They suggested that this might be a result of the techniques used in determining sterility and reported that studies indicated that bacterial invasion of the tissues of ham occurs during the dying period or postmortem. Invading bacteria may come from the pickle flora and/or contamination of the meat during handling. Garrard and Lockhead *(5)* reported that 26 of the species of bacteria, which were found to contaminate hams prior to pickling, reduced nitrate to nitrite.

Niven *(15)* stated that with the present day practice of using a mixed nitrate-nitrite cure, bacteria are not so important as when nitrite was not allowed as a constituent of curing formulas. In 1925 the use of sodium nitrite not exceeding 200 p.p.m. was authorized. Several workers *(2, 10, 11)* have reported that hams could be successfully cured with sodium nitrite alone. Rose and Peterson *(16)* reported that a non-bacterial reduction of nitrite also occurs in pork.

Hugli and Prudent *(8)* reported that the formation of nitric oxide hemochromogen in cooked ground beef when nitrate was added, could be prevented by adding streptomycin to the meat, but was not prevented by adding subtilin. They concluded this indicated that the reduction of nitrate was of bacterial origin.

Wilson *(19)* reported that a panel of 11 judges in judging color preference ranked cured hams which had sodium tripolyphosphate and sodium hexametaphosphate added to the cure higher than those which had had no phosphate added. Disodium phosphate did not affect the color. Wilson also reported that "the addition of phosphates to a comminuted product produced no observable benefit with respect to color fixation or rate of fading." Frank *(4)* reported that an untrained taste panel thought there was better color retention in ground meat for frankfurters to which phosphate had been added. Brissey *(1)* in describing his process for adding disodium phosphate to cures for meat stated that it resulted in an improved resistance to discoloration.

No reports were found in the literature on the effect of adding surplus animal fat to the diet on color of cured hams. Purpose of this part of the study was to study color in relation to the diet and cure employed in this experiment *(14)*.

EXPERIMENTAL

The history of the feeding of the pigs, slaughter, and methods of preparation for curing, curing, smoking, sampling and roasting of hams, and statistical design and analysis of data are given in Part I of this study *(14)*.

Determination of color of uncooked and cooked hams. The Rd, a and b values of the biceps femoris muscle were

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[e] The antibiotic (Aurofac) was added in amounts to furnish 0.5% of the diet. This amount contributed 9 mg. of chlortetracycline and 9 mcg. of vitamin B_{12}, per pound of feed.

measured with the Hunter Color and Color-Difference Meter. The operating procedure supplied by the manufacturer was followed. For both the uncooked and cooked ham the machine was balanced with a standard color plate having values of Rd 6.6, a + 34.6, and b + 16.0. Each slice was exposed to the air for 30 minutes before the color was read.

The color was reported as a/b ratio. Robinson [1] stated that "the a/b ratio is a good factor to use in some color work since neither 'a' nor 'b' means much by itself. The ratio a/b is directly related to hue; the greater the ratio, the redder the hue."

RESULTS AND DISCUSSION

Color values. The experimental mean of the a/b color ratios (hue) of the uncooked hams was 1.39, and that of the cooked hams 0.90 (Table 1).

TABLE 1
Means for objective color values of smoked hams

Treatment		a/b Color Ratios	
Diet	Cure	Uncooked	Cooked
Basal	Control	1.31	.97
	PO_4	1.34	.91
Antibiotic Supplement	Control	1.39	.89
	PO_4	1.33	.89
Fat Supplement	Control	1.42	.93
	PO_4	1.44	.88
Antibiotic and Fat Supplement	Control	1.42	.89
	PO_4	1.47	.81

There were highly significant differences in the a/b values of the hams from pigs within diets.

Diets. No statistically significant differences in a/b ratios of the ham either before or after roasting which could be attributed to diets were found (Table 2).

Luther *et al. (13)* reported that no antibiotic appeared in tissue until 200 g. of Terramycin per ton of feed was fed. Broquist and Kohler *(3)* did not find residues in meat from animals that had been fed antibiotics at levels below 20 g. per ton of feed. In the study reported herein the antibiotics were fed at a level of 18 g. per ton of feed. One might postulate from this that there were probably no residues of antibiotic in the meat which might possibly alter the bactereial flora.

TABLE 2
Mean squares and significance of objective color values for smoked hams

Variables	df	a/b Color Ratio	
		Uncooked	Cooked
Diets	3	.0563	.0225
Pigs within Diets	27	.0817**	.0413**
Cures	1	.0024	.0347
Diets x Cures	3	.0090	.0046
Error B	27	.0254	.0087

**Significant—1% level.

Stokstad *(18)* also reported that broiling chicken 30 minutes completely destroyed aureomycin present in the raw muscle.

Possible reasons for the color of the unroasted cured ham not being affected by the feeding of antibiotics include (a) the possibility that no antibiotic was present in the tissue, (b) bacteria might not be necessary for color development and fixation since nitrite was present in the cure, (c) non-bacterial reduction of nitrate to nitrite might have occurred.

It was not expected that the feeding of surplus fat would affect the color of the cured ham.

Cure. There were no statistically significant differences in a/b values of the ham either before or after roasting owing to the addition of disodium phosphate to the cure (Table 2).

In this study no attempt was made to correlate a/b values and color acceptability scores as given by a panel of judges *(14)*, since they did not measure the same quality.

There was no correlation between the a/b values and the percent fat in the uncooked lean ham. Hankins and Ellis *(7)* suggested that the increase in muscular fat might decrease the intensity of the color of lean beef or lamb. These workers, however, found no significant correlation between percent fat in lean beef and the color as measured by a spinning disk. In this study of pork the range of fat content, 3 to 6%, was apparently not large enough to affect the color in the lean of smoked ham. Furthermore, there was not the contrast in color of lean and the color of marbling fat that there is in raw beef.

SUMMARY

A study was made of the effect of adding an antibiotic, adding surplus animal fat, and adding both an antibiotic and waste animal fat to the diet of growing-fattening pigs and of adding disodium phosphate to the curing brine on the color of 62 smoked hams both before and after roasting. Eight hams were assigned to each diet and one ham from each pig was assigned to a phosphate cure while the other ham was assigned to a control cure.

Color was determined with a Hunter Color and Color-Difference Meter and reported as a/b ratio or hue.

There were no significant differences in the a/b values of the lean meat of uncooked hams or cooked hams which could be attributed to the diets of the pigs, to the curing of the hams, or to interaction between diets and cures.

There was a highly significant difference in the a/b values of lean ham from pig to pig within diet.

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The Quality of Smoked Hams as Affected By Adding an Antibiotic and Fat to The Diet and Phosphate to the Cure. III. Moisture, Fat, Chloride and Thiamine Content

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(Manuscript received February 13, 1956)

The effect of adding antibiotics or fat to the diet, or phosphate to the cure on the moisture, fat, chloride, or thiamine content of smoked hams has not been reported in the literature. In the articles reviewed below, control diets and cure were apparently used.

Moisture contents reported in the literature ranged from 61.9 to 69.1% *(2, 5, 8)*. Hoagland *et al. (8)* reported that artery-cured hams in 2 experiments averaged 69.1 and 66.9% moisture, dry-cured hams 62.0 and 61.9% and brine-cured hams 64.0 and 62.9%. Fields and Dunker *(5)* reported that 3 types of sweet pickle brine-cured hams had similar average moisture content: tendered 67.9, ready-to-eat 68.6 and long-cured 67.1%. Cecil and Woodroof *(2)* found moisture content of "country-style hams" to be 65.4%.

Fat contents of lean ham reported ranged from 5.8 to 8.4% *(5, 8)*. Hoagland *et al. (8)* reported that artery-cured hams in 2 experiments averaged 5.8 and 6.8% fat; dry-cured hams 8.4 and 7.7% and brine-cured hams 7.6 and 7.8% fat. Fields and Dunker *(5)* reported that 3 types of sweet pickle brine-cured hams had similar fat content: tendered 7.2, ready-to-eat 6.4 and long-cured 6.0%.

Chloride contents reported ranged from 3.62 to 6.93% *(5, 8)*. Hoagland *et al. (8)* reported salt content of smoked ham as: dry cure 4.28 and 5.51%, arterial-cured 5.41 and 6.03%, and brine cured 6.01 and 6.93%. Fields and Dunker *(5)* reported average salt content of tendered hams as 4.03%, of ready-to-eat 3.62% and long-cured 5.21%.

Thiamine contents have been reported in a wide range. Waisman and Elvehjem *(13)* gave from 2.10 to 2.70 mg. of thiamine per 100 g. of ham on the dry weight basis. Hoagland *et al. (8)* found from 0.519 to 0.874 mg. per 100 g. of ham on the wet basis. Dunker *et al. (4)* reported an average of 2.9 mg. per 100 g. of protein but found a wide range in 53 samples of 0.66 to 6.3 mg. per 100 g. of protein. Rice *et al. (12)* reported from 0.0682 to 0.1136 mg. of thiamine per 100 g. of meat and 4.05 to 6.34 mg. per 100 g. of protein.

The purpose of this phase of the study was to consider the foregoing factors (moisture, fat, chloride, and thiamine) in relation to the diet and cure selected *(9)*.

EXPERIMENTAL

Methods. *Sampling and Grinding of the Hams for Chemical Analysis.* The parts of uncooked lean ham remaining after samples for shear force and color determinations were taken, and those of the roasted ham remaining after samples for shear force, color and palatability tests *(6, 9)* were taken, were used for chemical analysis.

Both the uncooked and cooked lean ham were cut into approximately 1-inch cubes and mixed well by hand for 1 minute. The meat was ground in an institution type electric grinder with the coarse knife at a slow speed (No. 1). All of the lean meat was ground once and then mixed thoroughly by hand for 1 minute. The uncooked meat was ground and mixed 2 more times. A representative sample of approximately 600 g. was removed from the cooked meat and ground a second time followed by 1 minute of mixing. A representative sample was then removed for each analysis.

Chemical Determinations. Moisture was determined by the AOAC *(1)* method by vacuum drying with the exception that the meat was dried for 7 hours.

TABLE 1

Mean values for chemical determinations on smoked hams

Treatment		% Moisture		% Fat		% Chloride		Thiamine,[1] mg./100 g.	
Diet	Cure	Uncooked	Cooked	Uncooked	Cooked	Uncooked	Cooked	Uncooked	Cooked
Basal	Control	68.22	63.14	4.46	6.62	2.91	2.08	1.87	1.63
	PO_4	67.94	62.83	4.37	6.65	2.91	2.04	1.80	1.47
Antibiotic Supplement	Control	67.49	62.68	3.92	5.80	3.22	2.30	2.16	1.87
	PO_4	68.01	63.81	4.11	5.53	3.05	2.56	2.19	1.76
Fat Supplement	Control	68.46	64.22	3.73	5.80	2.97	2.43	2.19	1.77
	PO_4	68.06	64.17	4.05	5.53	2.86	1.99	2.37	1.79
Antibiotic + Fat Supplement	Control	69.11	64.07	4.05	6.59	2.84	2.30	2.29	1.65
	PO_4	68.07	63.50	4.66	6.82	2.87	2.13	2.23	1.72

[1] Moisture, fat, chloride-free basis.

Fat was determined by a method adapted from the Babcock AOAC method for milk *(1)*.

Chloride was determined by a modified Volhard method (11).

Thiamine was extracted from the ground lean meat by the method of Watts *et al. (14)* with slight modifications and was measured by the thiochrome method of Conner and Straub *(3)*.

Statistical Design and Treatment. These were described in Part I of this study *(9)*.

RESULTS AND DISCUSSION

Statistically significant differences (1% level) were found from pig to pig within diet (Table 2) in moisture, fat, chloride and thiamine content of the uncooked hams. Differences in moisture and salt contents were apparently obliterated by cooking.

Moisture. Mean of moisture content of uncooked lean ham was 68.15%; that of cooked hams was 63.55% (Table 1). Moisture content of uncooked hams was similar to that reported for arterial-pumped hams, 67.0 to 71.2% by Fields and Dunker *(5)* and higher than the 49.8 to 53.2% which they reported for dry-cured hams.

No differences in moisture content of either uncooked or roasted ham were found which could be attributed to diet or to cure. Pierce *(10)* reported that antibiotics in the diet had no statistically significant effect on the moisture content of lean fresh pork. Frank *(7)* found that the addition of any one of 6 inorganic phosphate compounds had no effect on water-binding capacity of comminuted meat after the protein had been coagulated by heat.

Fat. Mean values for the fat content of uncooked hams was 4.16%, and for cooked 6.35% (Table 1). Values for the uncooked ham were slightly lower than those reported by Hoagland *et al. (8)*, averages of 5.8 and 6.8% in artery-pumped, and 7.6 and 7.8% in dry-cured hams.

Values for cooked hams were similar to those reported by Fields and Dunker *(5)* for uncooked tendered, ready-to-eat and long brine-cured hams.

No significant differences in fat content of uncooked hams owing to diet were found. Although significant differences owing to cure occurred (Table 2), the difference of 0.25 was probably too small to be of practical significance.

No significant differences in fat content of roasted ham resulted from diets or from cure.

Chloride. Mean chloride content of uncooked smoked hams was 3.05%, and of cooked hams 2.19% (Table 1).

Diet treatments did not significantly affect the chloride content of the uncooked or roasted ham.

Although differences between chloride content of the uncooked phosphate-cured and control-cured hams were statistically significant at the 5% level (Table 2), the mean difference was only 0.08%. This small difference was apparently obliterated by cooking.

The chloride content of the uncooked ham was slightly less than the mean of 4.03% (3.36 to 4.48) reported by Fields and Dunker *(5)* for tendered hams which had been arterial-pumped and then immersed in cover pickle for 10 days.

Thiamine. Mean thiamine content of uncooked lean ham was 0.527 mg. per 100 g. of meat on the wet basis, and 2.14 mg. per 100 g. on the moisture, fat, chloride-free basis (Table 1).

No significant differences in thiamine content of uncooked or cooked lean ham could be ascribed to diet or to cure (Table 2).

Mean thiamine content of cooked lean ham was 0.476 mg. per 100 g. of meat on the wet basis, and 1.71 mg. per 100 g. of meat on the moisture-fat-chloride-free basis (Table 1). Waisman and Elvehjem *(13)* reported that fried ham had a mean thiamine content of 2.90 mg. per 100 g. of meat on the dry basis. Long cooking

TABLE 2

Mean squares and significance of chemical values for smoked hams

Variables	df	% Moisture		% Fat		% Chloride		Thiamine, mg./100 g.	
		Uncooked	Cooked	Uncooked	Cooked	Uncooked	Cooked	Uncooked	Cooked
Diets	3	3.45	5.78	1.10	3.64	0.232	0.131	0.00711	0.00216
Pigs Within Diets	27	2.63**	2.68	0.907**	1.80**	0.242**	0.155	0.00408**	0.00223**
Cures	1	1.38	0.083	0.965*	0.101	0.0743	0.506	0.000064	0.000405
Diets x Cures	3	1.60	2.12	0.306	0.269	0.0332	0.139	0.000523	0.000427
Error B	27	1.01	1.53	0.176	0.549	0.0615	0.0895	0.000568	0.000356

*Significant—5% level.
**Significant—1% level.

periods, approximately 4 hours, with dry heat are probably at least partially responsible for the lower thiamine content of the cooked hams in the experiment reported herein. Rice *et al. (12)* reported that smoked hams after boiling contained 5.20 and 3.22 mg. of thiamine per 100 g. of protein.

SUMMARY

The effect of the addition of an antibiotic, a surplus animal fat, and an antibiotic plus a surplus animal fat to the diet, and disodium phosphate to the cure on the moisture, fat, chloride, and thiamine content of lean tissue of smoked hams was studied. Analyses were made on 62 hams from Yorkshire hogs both before and after roasting in a 148.8° C. (300° F.) test oven to an internal temperature of 76.6° C. (170° F.).

There were no statistically significant differences owing to diet or to cure in the moisture, fat, chloride or thiamine content of either the uncooked or roasted hams.

Under the conditions of this experiment indications are that moisture, fat, chloride and thiamine contents of either the uncooked or roasted hams were not appreciably affected by the diet or by the cure treatments studied.

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Further Studies on the Preparation of Potato Granules by Solvent Methods

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(Manuscript received January 19, 1956)

Dehydrated cooked mashed potatoes continue to be more widely used in households and institutions because of convenience in preparation. Their popularity and availability will be further increased as research and development improve their quality and find more economical and efficient methods for their production. Potato granules are enjoying a wide sale, a potato product in the form of shreds has been test-marketed in several cities, and a new form of dehydrated mashed potatoes known as potato flakes is in the development stage *(2, 3)*.

Studies on potato granules have sought to improve the add-back method and to determine the effects of different processing variables on granule quality *(1, 8, 9)*. These studies have emphasized that abrasion and impact must be minimized during drying. The powder that is produced must consist of discrete particles. These particles, although they may include some agglomerates of several cells each, are mainly individual cells. If these cells are broken during processing, the quality of the product is impaired due to the liberation of starch. Consideration has been given to replacing the pneumatic driers normally used by the industry with new types, such as the improved airlift and fluidized bed driers, which are designed to minimize damage to the potato cells.

Research has not only sought to reduce cell damage in the production of potato powder, but also to eliminate the add-back step and to avoid exposure of the potatoes to excessive heat. One method of attaining the latter objectives is that developed by a group at Kansas State

* A laboratory of the Eastern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

College. This consists of freezing the mash, thawing, pressing out much of the juice, and then drying the partially dewatered potatoes. The most recent work on this method and on the properties of the product has been done by Hall *(5)*.

PREPARATION OF GRANULES BY SOLVENT METHODS

The preparation of granules by solvent methods also permits mild drying conditions to be used and the add-back step to be circumvented. One such procedure consists in removing most of the water from the mash by extraction with water-miscible organic liquids such as alcohol and dehydrating by a series of suspensions and filtrations. This method, which is described in a previous paper from this laboratory *(6)*, is simple, but has the disadvantage that about 7 to 10% of the total solids of the potatoes are extracted along with the water.

A second method used at this laboratory to dehydrate mashed potatoes with alcohol was based on a special type of distillation. Alcohol was added to the mash contained in a specially designed rotating evaporator *(4)* which was operated under such conditions that a relatively large amount of water distilled with the alcohol. Most of the water was removed by distillation, although a subsequent filtration was employed to remove the water and alcohol remaining in liquid form. Loss of potato solids was only 2 to 3% in the distillation method. However, dehydration by distillation was found to have certain drawbacks, particularly the long time required for water removal and the relatively high alcohol requirement.

As a further improvement in drying through the use of alcohol, dehydration of a mashed-potato suspension was effected by using optimum conditions under which water passes through a cellophane membrane at a substantially greater rate than alcohol. Passage of water through the wall of a collodion bag and subsequent evaporation of the liquid from the outer surface was first observed by Kober *(7)*, who called this phenomenon *pervaporation*. There are only a few references on the subject in the literature, and this technique seems to have been largely overlooked in dehydrating suspensions and solutions.

DEHYDRATION BY PERVAPORATION

Loss of potato solids is quite low when mashed potatoes are dehydrated by pervaporation. The alcohol requirement is also considerably lower than with either the suspension-filtration or distillation method. In pervaporation, the major part of the dehydration of a mashed-potato suspension in alcohol takes place by transmission of the water through the cellophane. Only a minor portion of the water is removed by a filtration step following the pervaporation.

When a solution of equal parts by weight of alcohol and water was placed in a cellophane bag, suspended in a forced-draft oven maintained at 60° C., the water content of the aqueous alcohol that passed through the membrane was about 70%. (The bags were formed from seamless regenerated cellulose sold specifically for dialysis; although wall thickness was not critical, 0.0016-inch membrane was ordinarily used). However, when a suspension of mashed potatoes in 1:1 alcohol-water was treated in the same manner, the water content of the pervaporated vapor was about 95%. Essentially the same result was obtained when the filtrate from mashed potato-alcohol-water mixture was pervaporated, indicating that the higher ratio of water:alcohol must be due to presence of the soluble potato solids.

Some consideration was given to the question of what types of solutes affect the ratio of water:alcohol passing through a cellophane membrane. Soluble solids in potatoes consist principally of sugars, citric and other organic acids, nitrogen compounds, and inorganic salts. The naturally occurring mixture of water-soluble potato solids is also soluble in 1:1 alcohol-water but only slightly soluble in alcohol. It is granted that solubilities of the individual substances in the complex mixture are undoubtedly influenced by the presence of the other substances. However, it was deemed worthwhile to investigate a few model systems in which pure substances of different solubilities in water and in alcohol were added, one at a time, to a 1:1 alcohol-water solution.

Addition of substances soluble in alcohol but only slightly soluble in water decidedly reduced the percentage of water in the transmitted vapor. However, addition of substances soluble in water but only slightly soluble in alcohol markedly increased the percentage of water in the pervaporated vapor. Addition of citric acid, soluble in both water and alcohol, resulted in pervaporated vapor of virtually the same composition as the control containing only alcohol and water.

Measurements taken periodically showed that the pervaporation rate of alcohol from a potato solids-alcohol-water mixture decreased with time and was finally reduced to an exceedingly low level. Alcohol passage was not detectable after 3 hours in an experiment at 42°-45° C. and after 22 hours at 25°-28° C. It is remarkable that by some mechanism the rate of transfer of alcohol through cellophane is diminished to this unmeasurably low level while water is being transmitted at a rapid rate. However, perhaps the most striking observation in this study is that temperature rise increases the pervaporation rate of water to a greater extent than the alcohol rate. In the laboratory preparation of granules, we have ordinarily employed 60° C. rather than a lower temperature in order to provide a high water transfer rate while transmission of alcohol is held to a low value.

TYPICAL LABORATORY PROCEDURE

An example of a laboratory procedure is as follows: Approximately 1000 g. of peeled potatoes (22% total solids) were sliced into ¾-inch pieces, steamed 35 minutes and mashed for 2 minutes at high speed in a planetary action mixer. Approximately 745 g. of absolute alcohol were added to the mashed potatoes and mixed to produce a slurry. The slurry was poured into a cellophane bag 1⅞ in. inflated diameter and suspended in a forced-draft oven maintained at 60° C. Pervaporation was continued until 60% of the water originally present had been removed. This required about 8 hours, the rate of pervaporation of water being approximately

0.15 g./sq. in./hr. The composition of the slurry before and after pervaporation is given in Table 1 (A). It can be seen that 472 g. of water diffused through the bag while only 20 g. of alcohol passed. The slurry was then fortified with 530 g. of absolute alcohol, which brought the liquid phase up to 80% alcohol. This is necessary to obtain a high percentage of single-cell particles in the final product. The effect of concentration of alcohol in contact with the potato solids on the yield of unicellular particles was discussed in our previous paper *(6)*.

The slurry was filtered with suction for 15 minutes, after which the filter cake weighed 400 g. [Table 1 (B)]. This filtration removed 261 g. of water, or 33% of that originally present. It will be noted that the ratio of alcohol : water was higher in the slurry than in the filter cake. This was due to evaporation occurring during the vacuum filtration. The vapor was condensed and recovered by a dry ice trap and added to the filtrate to be included for materials balance purposes. The alcohol was then evaporated from the filter cake while it was reduced to a free-flowing moist powder by application of gentle agitation and mild heat [Table 1 (C)]. The temperature was not allowed to exceed 45° C. during evaporation of the alcohol. This was done to obtain a product virtually free of residual alcohol. Higher drying temperature results in retention of an appreciable amount of alcohol in the dry powder. The vapor from the evaporation step can also be condensed in a dry ice trap. The substantially unicellular powder obtained at the end of the evaporation step contained 16% moisture and is reducible to a lower value by tray drying or other means available. The powder, however, should not be exposed to temperatures exceeding 80° C. for more than ½ hour. In the example given [Table 1 (D)], the powder was dried one hour at 60° C. to reduce the granules to 6.8% moisture content.

TABLE 1

Dehydration of cooked mashed potatoes using pervaporation

Step	Weight in grams			
	Water	Alcohol	Potato Solids	Total
A. *Pervaporation*				
Original slurry	786	744	220	1750
Final slurry (after 8 hr.)	314	724	220	1258
Vapor	472	20	0	492
B. *Filtration*				
Slurry (alcohol added)	314	1254	220	1788
Filter cake	53	131	216	400
Filtrate	261	1123	4	1388
C. *Evaporation*				
Filter cake	53	131	216	400
Moist powder	41	0	216	257
Vapor	12	131	0	143
D. *Drying*				
Final product	16	0	216	232

In the typical experiment outlined in Table 1, 1527 g. of aqueous alcohol would have to be distilled to recover 1254 g. of absolute alcohol. This amount of absolute alcohol, plus makeup of 20 g. to replace the alcohol transmitted in pervaporation (the recovery of which was not attempted) was used in preparing 232 g. of final product. Expressed in another way 550 parts of alcohol, of which 541 are readily recoverable, are used to produce 100 parts of granules. In this materials balance, the small amount of alcohol lost in the azeotropic distillation to obtain absolute alcohol is neglected.

POSSIBILITIES ENVISIONED FOR PERVAPORATION IN THE FOOD INDUSTRY

Pervaporation of an aqueous alcoholic suspension of potato solids has not been attempted on a large scale. It is envisioned, however, that such a process could be developed, perhaps by pumping the slurry through a continuous section of cellophane tubing contained in a tunnel through which heated air is forced. In addition to its possible application in dehydrating mashed potatoes, this principle might also be used in other food work, such as in dehydrating aqueous alcoholic extracts of flavoring substances or in dehydrating plant tissue under mild conditions. In any event, these laboratory studies have shown that pervaporation can be used successfully to remove most of the water from mashed potatoes in the preparation of granules, and that granules so prepared have good color and unusual storage stability, and reconstitute to mashed potatoes of good flavor and texture.

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Consumer Studies on Sweetness of Canned Cling Peaches

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(Manuscript received February 16, 1956)

FOR SEVERAL YEARS consumer reactions to various California food products have been studied at the California State Fair *(3, 8)*. Information obtained in this manner has been valuable in anticipating the acceptability of new products as well as evaluating consumer responses to existing products. In addition, the fair program provides a medium for basic studies on the methodology of organoleptic testing at the consumer level. The text of this paper illustrates that the acceptability of canned cling peaches can be correlated with chemical characteristics of the raw and processed fruit.

The object of the surveys was to establish the degree of sweetness that would be most acceptable to consumers when canned peaches are served as a dessert. The high acceptability of this fruit is reflected in statistics compiled by the National Canners Association *(6)*. Approximately 189 million cases[a] of peaches were commercially canned in the U. S. in the years 1945 through 1954, compared with 110 million cases of the second ranking fruit. Those canned peaches generally used as a dessert fruit range from 19° to 30° Brix, controlled by U. S. D. A. standards *(11)*. The sweetness of canned fruits is directly correlated with the soluble solids content expressed as ° Brix.

A consumer's acceptance of canned fruit and fruit juice is based largely upon the sweetness-acid-flavor relationship *(1, 2, 10, 16)*. This relationship in canned cling peaches was investigated through consumer surveys at the California State Fair in 1954 and 1955.

MATERIALS AND METHODS

For the 1954 survey, canned, diced Fortuna cling peaches were used. These peaches were harvested from the Marysville district, one of the 4 principal peach-growing areas in California, and immediately transported to the pilot plant of the Department of Food Technology at Davis. The peaches were sorted under a standard light source for defects, size, and maturity (skin color) and canned by rigidly controlled commercial procedures.

A blend of 2½ to 3 in. peaches of optimum maturity was used for the pack. The fruit was knife-pitted and conveyed through a cupdown spray peeler and washer. The halves were then diced into ½ in. cubes. No 2½ cans were filled with 21½ oz. of the diced fruit and 230 ml. of granulated cane sugar syrup. The syrup concentrations used were 35°, 45° and 55° Brix. After vacuum sealing, the cans were cooked for 29 minutes in a rotary atmospheric cooker, and then cooled to 100° F. in cold water.

Chemical analyses on the raw, peeled fruit were made to determine soluble solids (° Brix), pH, total acidity, and Brix/acid ratio (Table 1). Harvesting, sorting, chemical analyses, and canning were performed the same day.

An ample time interval permitted the fruit and syrup to equilibrate before the peaches were submitted for appraisal at the Fair. The chemical analyses of the canned fruit, approximately 30 days after canning, are reported in Table 2. The ° Brix cut-outs of these peaches were 17.4°, 21.5° and 24.2°.

The consumer tests were conducted in conjunction with those of the Consumer Reaction Council[b] of the California State Fair at Sacramento in early September. The physical arrangements provided by the Council are based on 20 serving windows in a series. Through each window a different sample of food or beverage is served to each participant, who then scores that product for degree of liking. Since the peaches were served at windows 19 and 20, each consumer would have tasted 18 different food items before sampling the peaches. Thus, the peach samples equated with the dessert portion of a meal, and the reaction of the consumers to the peaches of varying sweetness may be considered an indication of dessert quality.

For a critical evaluation of preference, an incomplete block, paired comparison design was selected as the means of presentation of the samples. Other workers *(12, 13)* have expressed the opinion that presentation of only two samples at a time allows the most critical comparison. A balanced procedure was followed in presenting the 3 combinations alternately to the participants so that approximately equal numbers of the comparisons were obtained. In order to off-set the natural bias of a preference for the first sample *(3, 5, 8)*, the order of presentation of each sample in any one of the 3 combinations was randomized. Therefore, approximately equal numbers of consumers received the following pairs of samples: 17.4° *vs.* 21.5°, 21.5° *vs.* 17.5°, 17.5° *vs.* 24.2°, 24.2° *vs.* 17.5°, 21.5° *vs.* 24.2°, 24.2° *vs.* 21.5° Brix.

The peaches were served at about 40° F., the normal temperature of canned fruit served as a dessert. Each participant received approximately 2 oz. of each sample in paper cups numbered "1" and "2". The consumer was asked to state his preference and indicate his sex and age group (under 18, 18 to 35, 35 to 50, over 50). Comments regarding the acceptability of the peaches were encouraged. The testing periods were from 10 a.m. to 12 a.m., and 1 p.m. to 5 p.m. for the 11 days of the Fair. A total of 2265 consumers participated in this survey.

When the results of this survey were tabulated, it was found that the sweetest sample presented was the preferred. It was impossible to conclude, however, whether the highest sweetness level was the optimum. Therefore, a similar survey was conducted at the State Fair in 1955, using canned peaches of a higher and wider sweetness range.

For this second study, it was impossible to obtain the Fortuna variety of peaches because of seasonal variation in growing conditions of the two years. The Halford variety was substituted.

TABLE 1
Chemical characteristics of raw peaches

Raw Peaches	° Brix[1] 20° C.	pH	Total acid (% citric anhyd.)	Brix/acid
1954 Fortunas	11.40	3.98	0.500	22.80
1955 Halfords	13.55	3.85	0.474	28.57

[1] Soluble solids measurement of pulped peaches by refractometer.

TABLE 2
Chemical characteristics of canned peaches[1]

Characteristics	In-going Syrup-°Brix									
	35°		45°		55°		65°		75°	
	'54	'55	'54	'55	'54	'55	'54	'55	'54	'55
° Brix, 20° C.[2] Cut-out	17.4	.....	21.5	23.5	24.2	26.7	.....	30.5	.....	34.5
Total acid (% citric anhyd.)	.319	.....	.352	.319	.296	.313	.....	.320	.....	.312
° Brix/acid	54.6	.....	61.1	73.7	81.8	85.4	.....	95.4	.....	110.6

[1] Preferred values are underlined.
[2] Soluble solids measurement of pulped peaches by refractometer.

[a] Twenty-four No. 2½ cans per case.

[b] The Consumer Reaction Council was established to provide a means whereby food processors in California can get an unbiased estimate of consumer acceptability of their products.

This variety has organoleptic and canning qualities similar to the Fortunas *(11)*. Harvesting, canning and survey procedures of 1954 were followed as closely as possible, with the exception of the in-going syrup concentrations. These included 45°, 55°, 65° and 75° Brix. Analyses of the chemical characteristics of the raw and canned fruit are reported in Tables 1 and 2, respectively. Comparison of the analyses indicates that the raw fruit used in the 1954 and 1955 packs was very similar. Cut-outs of the 1955 peaches were 23.5°, 26.7°, 30.5° and 34.5° Brix. With 4 levels of sweetness in the second series, the number of possible combinations was double that of 1954. A total of 4007 consumers participated in this second study.

The canned peaches of varying sweetness were presented both years to this department's panel of experienced tasters for evaluation of preferences, using the same experimental design as that employed for the surveys. Approximately 35 staff members participated in 4 tasting sessions, yielding 135 separate responses for each of the series. The preferred sweetness levels of these trained tasters were then compared with those of the consumers.

RESULTS AND DISCUSSION

The preferences are reported in percent to afford a means of comparing the various pairs of samples and consumer groups. Despite the attempt of the experimenters to balance the number of times each combination was presented, it was impossible to obtain exactly the same number of responses to each combination. The determination of statistical significance of the preferences was based on confidence intervals for a binomial distribution. Age group and sex distribution of the populations sampled at both fairs is reported in Table 3.

TABLE 3

Sex and age group distribution
Number of consumers

Year	Sex	Age Group				
		Under 18	18-35	35-50	Over 50	Total
1954	Male	367	304	139	93	903
	Female	453	373	295	241	1362
	Total	820	677	434	334	2265
1955	Male	821	566	258	206	1851
	Female	557	657	522	420	2156
	Total	1378	1223	780	626	4007

In the 1954 survey there was a decided preference for the sweeter samples in each pair by all 4 age groups and both sexes (Table 4). However, in 1955, when the range of sweetness levels was higher, a strong tendency existed among all groups to prefer the less sweet sample (Table 5). This indicates very clearly that the level of sweetness most acceptable to the fairgoers is somewhere between the highest level of 24.2° Brix served at the 1954 Fair and the lowest level of 23.5° Brix served at the 1955 Fair.

The reason for this conclusion can be seen more readily by referring to Table 6. The comparative preferences reported here provide a means of ranking the samples in each series on a relative basis, and thus allows for a comparison of the results of both surveys. Computation of the comparative preferences involved totaling the number of times each sample was presented with every other sample in the series, then dividing by the total number of times that sample was preferred. The underlined percentages in Table 6 indicate the preferred samples of both years.

TABLE 4

Age and sex distribution of preferences for canned cling peaches
California State Fair, 1954

Paired Comparisons	% Preferences						
	Age Group				Sex		Total
° Brix cut-out	under 18	18-35	35-50	over 50	Male	Female	
17.4° vs. 21.5°	38.2	34.4	37.8	33.5	35.1	37.0	36.3
	61.8[2]	65.6[2]	62.2[1]	66.5[2]	64.9[2]	63.0[2]	63.7[2]
17.4° vs. 24.2°	34.5	35.5	31.9	31.3	32.9	34.6	33.9
	65.5[2]	64.5[2]	68.1[2]	68.7[2]	67.1[2]	65.4[2]	66.1[2]
21.5° vs. 24.2°	44.5	43.8	35.7	48.4	42.9	43.5	43.3
	55.5[2]	56.2[1]	64.3[2]	51.6	57.1[2]	56.5[2]	56.7[2]

[1] 5% level of significance.
[2] 1% level of significance.

The difference in preference between the 23.5° and 26.7° Brix packs in the 1955 series is slight, with a tendency to favor the lower sweetness levels. There was a definite preference for the 24.2° Brix sample in the 1954 series. Thus, by comparing the results of the two surveys, the most acceptable level appears to be between 24° and 26° Brix.

Also reported in Table 6 are the preference ratings assigned to the peaches by the experienced tasters of the laboratory staff. It is apparent that these trained people were consistently prone to prefer less sweet canned peaches than were the fairgoers. This observation applies to other fruit products evaluated in this laboratory, and has been observed by other workers in the field *(4)*.

By referring to the chemical analyses of the canned fruit (Table 2), it can be seen that the acceptability of canned peaches is not only directly correlated with ° Brix cut-out, but also with the Brix/acid ratio. The preferred sample in 1954 had a ratio of 81.8 which falls

TABLE 5

Age and sex distribution of preferences for canned cling peaches
California State Fair, 1955

Paired Comparisons	% Preferences						
	Age Group				Sex		Total
° Brix cut-out	under 18	18-35	35-50	over 50	Male	Female	
23.5 vs. 26.7	47.1	53.3	56.6	51.1	49.0	53.7	51.5
	52.9	46.7	43.4	48.9	51.0	46.3	48.5
23.5 vs. 30.5	49.4	59.7[2]	58.2[1]	48.3	52.3	54.9	53.6
	50.6	40.3	41.8	51.7	47.7	45.1	46.4
23.5 vs. 34.5	54.1	63.1[2]	58.4[1]	50.5	53.5	60.7[2]	57.4[2]
	45.9	36.9	41.6	49.5	46.5	39.3	42.6
26.7 vs. 30.5	54.8	52.1	59.8[2]	48.9	53.1	54.9	54.2[1]
	45.2	47.9	40.2	51.1	46.9	45.1	45.8
26.7 vs. 34.5	54.5	61.2[2]	62.7[2]	52.9	55.8[1]	60.1[2]	58.0[2]
	45.5	38.8	37.3	47.1	44.2	39.9	42.0
30.5 vs. 34.5	52.1	57.9[2]	50.7	51.6	49.8	56.3[1]	53.4
	47.9	42.1	49.3	48.4	50.2	43.7	46.6

[1] 5% level of significance.
[2] 1% level of significance.

between the ratios of 73.7 and 85.4 of the most acceptable fruit in 1955. The work by Bayton and Bell *(2, 3)* on canned orange juices emphasizes this important relationship between sweetness and acid in the acceptability of fruit products. With the knowledge of the ° Brix and acid content of the raw fruit, simple manipulation of the ingoing syrup concentration and/or possibly the addition of acid would lend a means of predicting and improving the acceptability of various canned fruits. Other workers in this laboratory have reported the possibility of using the Brix/acid ratio of the raw fruit as a criterion for predicting the flavor preference of canned peaches *(10)*.

Further interesting observations from the results of the consumer surveys are worthy of mention. In both 1954 and 1955 there was a distinctly greater tendency for males to prefer the sweeter sample in any one pair than females. Laird and Breen *(9)* found this same tendency in a small consumer study designed to determine sweetness preference in pineapple juice. Working with 3 age groups (12-18, 20-40 and 50-68), these investigators reported that with increasing age there was an increasing tendency to prefer less sweet juice. However, in the present studies, this tendency was not apparent (Tables 4 and 5). The youngest and oldest age groups were more prone to prefer sweeter samples than were the two middle groups.

TABLE 6

Comparative preference[1]
Fairgoers and laboratory staff
Percent

Panel	° Brix Cut-out						
	17.4	21.5	23.5	24.2	26.7	30.5	34.5
1954 Fair	35.2	53.4	.....	61.4	.....	.....	.....
1955 Fair	.....	.....	54.2	.....	53.6	48.6	43.8
1954 Lab.	46.2	61.5	.....	42.0	.....	.....	.....
1955 Lab.	.....	.....	75.4	.....	51.5	43.5	28.8

[1] Preferred sweetness level expressed by underlined values.

Some of the participants' comments on the relationship of flavor to sweetness were most interesting. In 1954, when there was a significant preference for the sweeter sample, a tendency to ascribe more flavor to the sweeter sample was pronounced. However, comments regarding flavor quality in 1955 were minimized by the numerous comments indicating objectionable sweetness. A tendency to ascribe more flavor to the sweeter sample when the sweeter sample is preferred is in line with findings of investigators in this laboratory *(15)* and of Van Blaricom *(16)*.

The inability of some of the consumers to differentiate between samples which were adjacent in the series is shown in Tables 4 and 5. Participants receiving these pairs made such comments as "same," "no difference," "taste alike," etc. In 1955 when the sweetness levels were higher, this observation was more pronounced. Coupled with the consumers' inability to differentiate at the smaller increments is the effect of the Weber-Fechner law which states that the same absolute differences appear smaller at higher concentrations.

It has been pointed out by several workers in organoleptic appraisal *(3, 5, 8)* that the effect of serving order on subsequent ratings and preferences is pronounced. Results of the surveys reported in this paper indicate that critical, erroneous information can be obtained if precautions are not taken to compensate for this phenomenon. Table 7 clearly demonstrates the natural bias of preference for the first sample tasted. In all comparisons, a sample received a higher preference rating when it was served first, with one exception in 1955. This effect is so great in the comparisons of 23.5° *vs.* 26.7° and 23.5° *vs.* 30.5° Brix that the interpretation of the results would be completely reversed if the sweeter sample had always been served first. The bias was emphasized in these two comparisons in 1955 because of the proximity of the lower sweetness levels to the level of optimum acceptability.

SUMMARY

In 1954 and 1955, consumer surveys were conducted at the California State Fair to determine the most acceptable level of sweetness in canned cling peaches. Responses from over 6000 participants in the two-year program indicated that sweetness within the range of approximately 24° to 26° Brix was preferred. The acceptability can also be expressed in the Brix/acid ratio of the canned peaches, i.e., 73.7 to 85.4. Effect of degree of sweetness on the consumers' ability to discriminate between samples was apparent; the influence of serving order was stronger in the most acceptable range of sweetness levels.

Acknowledgments

The derivation of the method for determining significance of preference is credited to Dr. Terry Jeeves.[c] Chemical analyses were graciously performed by Dr. B. S. Luh and his students.

[c] Presently associated with the Westinghouse Corporation.

TABLE 7

Effect of serving order
Percent Preference

Year	Pairs (° Brix Cut-out)	Serving Order	
		1st.	2nd.
1954	17.4°	44.4	28.3
	21.5°	71.7[2]	55.6[1]
	17.4°	38.1	29.8
	24.2°	70.2[2]	61.9[2]
	21.5°	44.4	42.1
	24.2°	57.9[1]	55.6[1]
1955	23.5°	57.9[2]	42.1
	26.7°	57.9[2]	42.1
	23.5°	59.2[2]	47.2
	30.5°	52.8	40.8
	23.5°	59.7[2]	54.2
	34.5°	45.8	40.3
	26.7°	57.7[2]	50.2
	30.5°	49.8	42.3
	26.7°	55.0	61.2[2]
	34.5°	38.8	45.0
	30.5°	54.2	52.9
	34.5°	47.1	45.8

[1] 5% level of significance.
[2] 1% level of significance.

The assistance of Mrs. Gladys Jacob and Mrs. Doris Rogers in conducting the survey is greatly appreciated.

Funds for this work were made available by the Sugar Research Foundation.

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Effect of Sucrose and Organic Acids on Apparent Flavor Intensity. I. Aqueous Solutions

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(Manuscript received February 16, 1956)

Experimental work has shown that many opportunities exist in the processed food industry for improving flavor by the proper use of sweeteners. The effect on taste perception of adding small amounts of salt and monosodium glutamate to processed foods as well as the effect of these condiments when used in solutions, is quite well-known *(7, 8)*. But there is definite lack of published information on what can be accomplished by the addition of sweetening agents. It has been suggested *(2)* that such investigations should concern themselves initially with mixtures in solution of pure chemical compounds, which could thus be completely controlled. Results from these studies would then probably suggest suitable methods for testing accurately the natural mixtures in prepared food. Consequently, the present investigation was undertaken to determine whether increasing the sweetness level of a solution containing organic acids and synthetic flavoring enhances, depresses, or has no effect on the apparent flavor intensity.

The relationship between flavor impressions and sweetness levels has been investigated to a limited extent. In processed fruits and confections, sugar, used in quantities of 30% and above, imparts strong sweetness and thus becomes a major part of flavor *(4)*. In beverages, sugar, at a 10 to 12% level, adds "interest" and boosts the flavor *(4)*. Sucrose has been found to counteract some of the inherent sourness and to enhance the natural fruit character of strawberry preserves *(10)*, frozen peaches *(3)*, red raspberries, blackberries *(4)* and strawberries. Sweeteners used at low concentration improved the blending of the various flavor notes, and in many instances this was accompanied by an increase in the total flavor of the food *(9)*.

Employing solutions of chemical compounds, an untrained tasting panel found that higher concentrations of sugar (up to 35%) enhanced the flavor of orange and lemon oil flavored solutions *(5)*. In a solution of sucrose alone, a concentration of between 20 and 25% sucrose was most popular but with added orange or lemon oil (0.1 to 0.35 ml./100 ml.), a 25% sucrose solution was preferred *(5)*.

EXPERIMENTAL PROCEDURE

The solutions presented to the panel members for comparison consisted of various concentrations of sugar and raspberry flavoring in distilled water which contained 1.0% acid by weight (a mixture in the ratio of 1:2:6:11, of succinic, tartaric, citric and malic acids, respectively). It had been determined previously that these organic acids were present in most fresh fruits in this proportion. Two levels of imitation raspberry elements (Magnus, Mabee and Reynard, Inc., New York) were used: 0.001% and 0.0025%.

The investigation was divided into 4 parts employing the two mentioned flavor levels and 4 sets of sucrose concentrations. In each of the 4 series, the middle level used was always 13.75% sucrose with the sucrose range being increased with each successive set as follows:

1. 12.50%, 13.75% and 15.00% sucrose.
2. 11.25%, 13.75% and 16.25% sucrose.

3. 10.00%, 13.75% and 17.50% sucrose.
4. 8.75%, 13.75% and 18.75% sucrose.

A carefully selected and highly trained laboratory panel of 21 members, 8 women and 13 men, evaluated the solutions. The panel members included smokers as well as non-smokers, selected from a group of 30 individuals on the basis of their acuity in detecting small differences in concentration of sucrose and imitation raspberry flavoring. The tasting sessions were always held at mid-morning, in air-conditioned booths specifically designed for organoleptic analysis. Drinking fountains provided water for judges to rinse their mouths between tasting pairs of solutions. Although it had been reported *(2)* that perception of sweet tastes is most delicate at temperatures approximating that of the body, the samples were served at room temperature, approximately 78° F., to make them more palatable to the judges.

The solutions were presented in pairs. Each pair consisted of any two of the 6 possible combinations of flavoring and sucrose within a given series. This design included the possibility of the samples in a pair being identical. At each tasting session, each participant received 4 pairs of solutions and was asked to indicate whether the first sample presented in each pair had more, less or the same sweetness, and more, less or the same flavor intensity as the second sample. The order in which the samples were presented within a pair and the order in which the 4 pairs were arranged within a set was randomized. In order to offset the natural bias for the first sample presented *(1)*, each combination was served in the reverse order one-half of the time. Immediately after each tasting period, the judges were given the correct answers.

RESULTS AND DISCUSSION

As the difference in the sucrose concentration between paired solutions increased, the panel's ability to select the sweeter sample increased proportionally, up to a difference of 5.00% in sucrose concentration (Figure 1). Values of 100% or nearly 100% correct

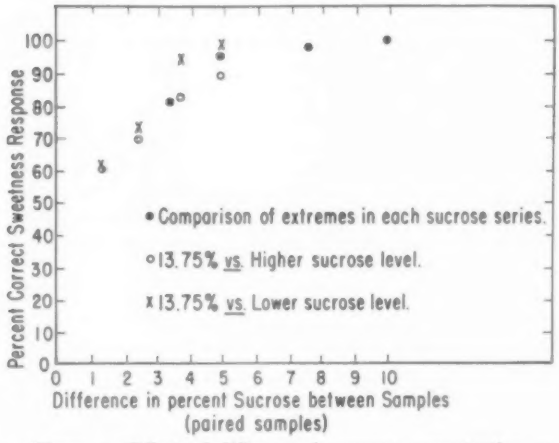

Figure 1. Effect of difference in sucrose concentration on sweetness discrimination.

responses were found whenever the difference in sucrose concentration reached 5.00% or more.

The group's ability to distinguish correctly between sweetness levels was dependent not only upon the percent sucrose difference between samples but also upon the actual amount of sucrose in each solution. Table 1 shows that greater accuracy in sweetness responses was obtained when 12.50% and 13.75% sucrose levels were

TABLE 1

Judges' response to sweetness and flavor of paired samples Flavor level kept constant within each pair

Diff. in % sucrose between samples	Sucrose levels used	Factor evaluated	Judges' response to sol'n with higher sugar conc.			Total No. eval.
			Same	More	Less	
			%	%	%	
1.25%	12.50 vs. 13.75%	Sweetness	26.0	63.5†	10.5	
		Flavor	42.7†	32.3	25.0	96
1.25%	13.75 vs. 15.00%	Sweetness	29.2	61.5†	9.3	
		Flavor	43.8†	35.4	20.8	96
2.50%	11.25 vs. 13.75%	Sweetness	25.3	74.7†	0.0	
		Flavor	41.8†	36.3	21.9	86
2.50%	12.50 vs. 15.00%	Sweetness	10.4	81.3†	8.3	
		Flavor	39.6†	34.9	25.5	96
2.50%	13.75 vs. 16.25%	Sweetness	28.6	70.3†	1.1	
		Flavor	43.9†	29.7	26.4	96
3.75%	10.00 vs. 13.75%	Sweetness	4.2	93.8†	2.0	
		Flavor	18.8†	50.0	31.2	96
3.75%	13.75 vs. 17.50%	Sweetness	15.6	82.3†	2.1	
		Flavor	34.4†	34.4	31.2	96
5.00%	8.75 vs. 13.75%	Sweetness	0.0	100.0†	0.0	
		Flavor	12.5†	57.3	30.2	96
5.00%	11.25 vs. 16.25%	Sweetness	3.3	95.0†	1.7	
		Flavor	36.1†	38.3	25.6	96
5.00%	13.75 vs. 18.75%	Sweetness	10.4	88.5†	1.1	
		Flavor	30.2†	29.2	40.6	96
7.50%	10.00 vs. 17.50%	Sweetness	0.5	97.9†	1.6	
		Flavor	20.3†	49.5	30.2	96
10.00%	8.75 vs. 18.75%	Sweetness	0.0	100.0†	0.0	
		Flavor	16.1†	59.4	24.5	96

† Indicates correct responses.

compared than when the comparison was between 13.75% and 15.00% sucrose, although the difference between solutions in both pairs was 1.25% sucrose. This condition increased as the sucrose increments increased to 2.50%, 3.75% and 5.00% (Figure 1). These results are what would be expected in accord with the Weber-Fechner Law since the relative difference in sweetness is greater at the lower concentrations.

Information collected from comparisons of solutions in which the flavor concentration was the same within each pair but in which the sucrose level differed is presented graphically in Figure 2. The outstanding feature of this graph is the definite effect the absolute sucrose concentrations have on the panel's flavor responses.[a] When the middle sweetness value in each series, 13.75% sucrose, was compared with the lower sucrose levels, 12.50%, 11.25%, 10.00% and 8.75%, respectively, there was a definite linear relationship associating more flavor with the sweeter sample. Apparently the flavor, which was held constant within each pair, as previously stated, was enhanced by the added sweetness at these levels. The panel expressed this same opinion when they contrasted the extremes in each sucrose series. However, this situation was not repeated when the 13.75% sucrose solution was tasted along with the higher levels of 15.00%, 16.25%, 17.50% and 18.75% sucrose, respectively. In this case, it seems that the excess sweetness confused the tasters, resulting in the

[a] The reader should bear in mind that the judge had a one-third probability of correctly guessing either the sweetness or the flavor response.

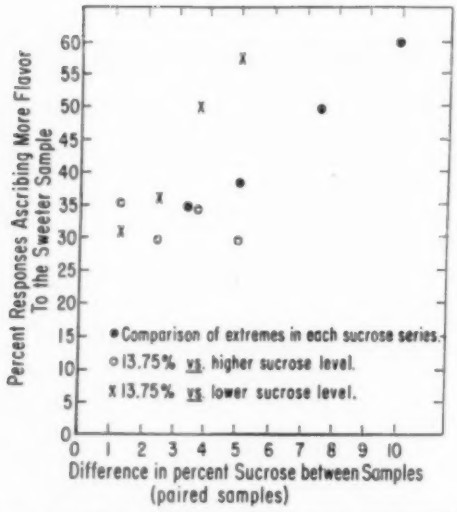

Figure 2. Effect of difference in sucrose concentration on apparent flavor intensity.

dispersion of the flavor responses among the three possible answers. The over-all picture suggests that there is an optimum level at which sweetness enhances the apparent flavor intensity in these solutions. There is also the possibility that the judges were basing their flavor response on either their preferred sweetness level or on their preferred sugar-acid ratio.

When the incorrect responses of the above-mentioned comparisons (Table 1) were analyzed, it was evident that the percentage of incorrect sweetness responses decreased with an increase in sucrose differences between samples. This condition was also accompanied by an increase in the percent incorrect flavor responses. The increase in number of incorrect flavor responses could be related, in part, to additional taste impressions attributable to the increasing sucrose concentration.

It has been speculated *(2)* that additional tastes are probably largely responsible for the different values found by different individuals in comparing sweetnesses of compounds and mixtures, through the variable intensity of the stimulus they produce in such persons. Dahlberg and Penczek *(6)* considered that their experienced judges could ignore any additional tastes in judging sweetness. Cameron *(2)*, with less experienced tasters, found that people with less delicacy of perception usually did not perceive an additional taste and were not misled by it. However, those individuals with very delicate taste perception were occasionally so influenced by the extra taste sensations they perceived, that they sometimes had difficulty in comparing sweetnesses, and in one or two instances were incapable of doing so. Cameron also reported that additional taste, inherent to various compounds, seems to become more perceptible when solutions of nearly equal sweetness are contrasted.

In relation to the above-mentioned observation, the reader's attention is called to Table 2 which presents a summary of results obtained when solutions of the same sweetness but of different flavor concentration were contrasted. A reason for the large number of responses incorrectly attributing more or less sweetness to the sample with the greater flavor may be postulated by assuming that the raspberry flavoring in these experiments behaves similarly to the additional flavor imparted by the artificial sweeteners used in Cameron's study. There was a slight tendency to associate sweetness with flavor by attributing greater sweetness to the more flavorful sample.

The incorrect responses for these comparisons (Table 2) show that as the solutions increased in sweetness, a larger percentage of responses indicated that the more flavorful sample was also sweeter. A sharp breaking point away from this trend can be seen at a sucrose level of 15.00%. As pointed out in discussing Figure 2, there is an optimum sucrose level beyond which the sweetness-flavor association trend ceases to manifest itself. Although the flavor may vary between two paired samples at sucrose levels beyond 15.00%, the excess sweetness interferes with or masks these flavor differences.

The final comparison studied in this investigation involved presentation of solutions which varied both in sweetness and in flavoring, employing all possible combinations. For comparison on a comparable basis these results were converted into one general category, i.e., that of the first sample of a pair being the sweeter as well as the more flavorful. Once again, as the sucrose

TABLE 2

Judges' response to sweetness and flavor of paired samples
Sucrose level kept constant within each pair

Composition of solutions			Factor evaluated	Judges' response to more flavorful solution			Total No. eval.
	Sucrose	Flavoring		Same %	More %	Less %	
Solution A	11.25%	0.0025%	Sweetness	75.0†	16.7	8.3	
Solution B	11.25	0.001	Flavor	50.0	40.0†	10.0	60
Solution C	12.50%	0.0025%	Sweetness	48.4†	25.0	26.6	
Solution D	12.50	0.001	Flavor	31.3	51.6†	17.1	64
Solution E	13.75%	0.0025%	Sweetness	56.5†	27.4	16.1	
Solution F	13.75	0.001	Flavor	45.2	41.1†	13.7	124
Solution G	15.00%	0.0025%	Sweetness	46.9†	34.4	18.7	
Solution H	15.00	0.001	Flavor	31.3	50.0†	18.7	64
Solution I	16.25%	0.0025%	Sweetness	61.7†	20.0	18.3	
Solution J	16.25	0.001	Flavor	36.7	48.3†	15.0	60

† Indicates correct response.

difference between samples increased, the percentage of correct responses for sweetness also increased. No generalization can be made concerning the flavor response, however, since the answers indicated the judges were confused when evaluating solutions which differed in the two characteristics.

SUMMARY

Paired solutions containing distilled water, organic acids, sucrose and synthetic flavoring were presented, in various combinations, to a highly trained taste panel. There were four sucrose levels and two flavor levels; the judges were asked to evaluate these two factors separately. The entire study was repeated four times, employing different sucrose concentrations. The panel's ability to distinguish between sweetness levels increased as the sucrose range increased, but their accuracy in detecting flavor differences decreased. Under the conditions of this study, there was a tendency for the panel to ascribe more flavor to the sweeter sample, especially as the difference in sucrose concentrations increased. However, there seemed to be an optimum level (about 15.00%) beyond which the excess sweetness interfered with the flavor perception. There was also a slight tendency to ascribe greater sweetness to the more flavorful solution. When samples varied both in flavor and in sweetness, inconclusive results were obtained.

Acknowledgments

The authors wish to acknowledge the assistance of Dr. Hans Abplanalp, Dept. of Poultry Husbandry, in setting up the experimental design. Appreciation is also extended to members of the taste panel and to Mrs. Gladys Jacob for her assistance in the laboratory.

Funds for the support of this investigation were provided through contract with the Sugar Research Foundation, Inc., New York.

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Antioxidant and Synergist Inhibition of Hematin-Catalyzed Oxidative Fat Rancidity[a]

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(Manuscript received March 5, 1956)

It is now well established that the hematin compounds—hemoglobin, myoglobin, and the cytochromes of animal tissues—are the predominant catalysts for unsaturated fat oxidation *(2, 13)*. The effectiveness of antioxidants and synergists in inhibiting oxidative fat rancidity in meat, poultry, and fish might be evaluated using simple reaction systems of water, unsaturated fat, hematin compounds, and oxygen. Watts and coworkers have been the first to use hemoglobin catalyzed oxidation of lard for the evaluation of antioxidants for use in meats *(4, 20)*. Other studies of antioxidants' inhibition of hematin catalysis are available *(1, 15, 16)*, but the results are not directly applicable to the design of antioxidant mixtures for addition to meats.

There is available a wide variety of phenolic food antioxidants and naturally occurring synergistic compounds *(7, 8, 14)* which could be used in formulating synergistic antioxidant mixtures for use in meats. Many studies of antioxidant and synergist inhibition of oxidative fat rancidity in pork *(5)*, poultry *(6, 9)*, and fish *(17)* have been based on the empirical evaluation of antioxidants in the meat product under commercial storage or simulated commercial storage conditions. Although remarkable success has been achieved in some cases these more laborious methods of antioxidant evaluation have not yielded information of general applicability to the prevention of oxidative fat rancidity in meats.

This paper describes the use of hemoglobin catalyzed lard oxidation in emulsion systems to evaluate inhibitors, antioxidants, and synergists for use in meats. The most effective synergistic system is further evaluated in accelerated oxidative fat rancidification in pork, turkey, and salmon.

[a] Aided by a grant from W. J. Stange Company, Chicago, Illinois.

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MATERIALS AND METHODS

Unsaturated fatty acid esters. Both purified and naturally occurring fatty acid esters were used in this investigation. The purified unsaturated esters included methyl oleate (iodine number 78.3, from Eastman Kodak Co.) and methyl linoleate (iodine number 144, from Nutritional Biochemicals Co.). The naturally occurring esters included cod liver oil (iodine number 164, from McKesson and Robbins), soy bean oil (iodine number 131, from Staley and Co.), and two lard samples (iodine numbers 54.2 and 51.2) obtained by kettle rendering pork adipose tissue purchased from a commercial source. The sample with iodine number of 51.2 was used in the synergist studies.

Hematin catalysts. The hematin compounds used in the study were purified horse heart cytochrome c (Sigma Chemical Co.), crystalline hemin (Armour and Co.) and hog hemoglobin. The hog hemoglobin was prepared and assayed as previously described *(12)*. The hematin catalysts were used at a final concentration of 10^{-4}M.

Primary antioxidants. Nordihydroguaiaretic acid (NDGA), butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate were preparations obtained from commercial sales organizations. Alpha-tocopherol was from the Nutritional Biochemicals Co. All of the antioxidants were added in ethanol solution to give a final concentration ranging from 10^{-2}M to 10^{-5}M in the 4 ml. of reaction system.

Synergists. Nitrogenous compounds, such as the amino acids, purines, etc., were from the Nutritional Biochemicals Co. Ascorbic acid (C.P.) was neutralized before addition to the reaction system.

Preparation of emulsion systems. The emulsions were prepared fresh before each experiment, as previously described *(15)*. Ten ml. of fat or oil was emulsified with 20 ml. of 0.1 M phosphate buffer, pH 7, by passing through a hand homogenizer three times. With the alkaline solution of hemin, 0.2 M buffer was used.

Determination of iodine value. Iodine values of the fatty acid esters were determined by the gravimetric method of Burton and Grindley *(3)*.

Measurement of oxygen absorption. Conventional manometric techniques with a Warburg respirometer were used to obtain oxygen absorption measurements at 0° and 37° C. Induction periods often occurred. The end of the induction period was characterized by a rapid increase in the rate of oxygen uptake. In some cases oxygen absorption began immediately and there was no induction period. After study of typical reaction rate data, the induction period was arbitrarily defined as the time required to reach 300 microliters of oxygen absorbed. Measurements of oxygen uptake required periods from 2 to 200 hours, readings being taken at intervals from 15 minutes to 24 hours depending upon the reactivity of the system.

Warburg flasks of 16 ml. volume containing 4 ml. of reaction system were used in the studies. Three ml. of unsaturated lipid emulsion and 0.5 ml. of water or ethanol or 0.5 ml. of antioxidant with or without synergist were placed in the main compartment and 0.5 ml. of catalyst was placed in the side arm. The flask was placed in the water bath and the catalyst was mixed with the lipid after temperature equilibration. Manometric readings were corrected for atmospheric pressure charges by use of a thermobarometer.

Protective index. For comparative purposes reporting of the effectiveness of a synergist or antioxidant in terms of "protective index" (also known in the literature as protection factor or protection number) was deemed most definitive. The "protective index" is the number found by dividing the induction period of the sample containing added antioxidant by the induction period of the control sample. All induction periods were determined from plots of the kinetic data.

Inhibition of oxidative rancidity in pork, turkey, and salmon adipose tissue. One-hundred gram pork, turkey, and fish samples were prepared from 75% adipose and 25% muscle. Each tissue was passed through a hand grinder 3 times and then divided into 4 samples: the control, the control plus propylene glycol solvent, a synergistic mixture of 0.0018% BHA, 0.003% NDGA, and 0.0018% ascorbic acid final concentration on a total weight basis, and a synergistic mixture of 0.02% BHA, 0.01% NDGA, and 0.47% ascorbic acid. The propylene glycol was thoroughly mixed with the ground tissue by means of a mortar and pestle. The meat samples were then made into balls weighing about 3 g. After placing the samples into an oxygen atmosphere in sealed jars, the jars were placed into an ice bath. Rancidity was determined by organoleptic evaluation in combination with iodometric peroxide determinations.

Pork adipose pieces, 1 cm^2., by 3 cm., were also dipped in antioxidant solutions and the stability was measured by oxygen absorption, organoleptic evaluation, and peroxide determinations.

RESULTS

Effect of hematin catalysts on the oxidation of various unsaturated lipids. Before choosing one reaction system for evaluation of inhibitors, antioxidants and synergists, it was desirable to compare the catalytic effects of hemoglobin, hemin, and cytochrome c on different unsaturated lipids at different temperatures. The unsaturated lipids—lard, cod liver oil, soy bean oil, methyl oleate and methyl linoleate—were catalytically oxidized at 37° C. and 0° C.

The resultant data in Table 1 show that, in general, the rates of reaction for the 3 catalysts when used in the same concentration of 10^{-4}M occur in the order:

$$\text{hemoglobin} > \text{hemin} \geq \text{cytochrome c}.$$

The change in the reaction rate with decrease in temperature is not the same for all 3 catalysts when used with different fatty acid esters. Hemoglobin catalysis of all the lipids resulted in decreased activity with decreasing temperature. The behavior of hemin was more erratic. A decreasing temperature gave a decreasing reaction rate with cod liver oil and methyl linoleate. This decrease in rate did not occur with the other lipids. The behavior of cytochrome c was generally similar to that of hemin.

TABLE 1

Comparison of the oxidation of various lipids catalyzed by hematin compounds at 37° C. and 0° C.

Lipid	Temp. °C.	Catalyst					
		Hemoglobin		Hemin		Cytochrome c	
		Time[1]	Rate[2]	Time	Rate	Time	Rate
Lard	37°	0	0.4	0	0.2	0	0.2
	0°	5	0.2	30	0.2	30	0.2
Cod liver oil	37°	0	2.5	5	0.8	5	0.3
	0°	5	0.3	30	0.3	30	0.1
Soy bean oil	37°	5	0.2	10	0.1	—	—
	0°	10	0.1	30	0.2	60	0.1
Methyl linoleate	37°	0	3.3	0	1.1	0	1.3
	0°	5	0.4	30	0.4	53	0.2
Methyl oleate	37°	0	0.5	45	0.1	—	—
	0°	10	0.2	30	0.1	99	0.1

[1] Minutes before initiation of oxygen uptake in the system.
[2] Milliliters of oxygen absorption 30 minutes after the beginning of oxygen uptake.

With hemoglobin the activity was approximately two to five times greater than either hemin or cytochrome c. Because of its reactivity, availability and similarity to myoglobin which is the major hematin compound in meats hemoglobin was chosen as catalyst for evaluation of antioxidants and synergists. The temperature of 37° C. was chosen primarily because it gave a reaction rate of the desired magnitude and because of the great physiological significance of hemoglobin-catalyzed oxidation of natural unsaturated fats. In these studies lard was used as unsaturated lipid because its rate of oxidation was not excessive and because it was a representative unsaturated lipid on which a large amount of research information is already available.

Inhibition of hemoglobin-catalyzed lard oxidation by five commercial antioxidants. Various concentrations of alpha-tocopherol, propyl gallate, NDGA, BHA, and BHT were evaluated as antioxidants of hemoglobin-catalyzed lard oxidation. The results are shown in Table 2. At concentrations of 10^{-3}M, NDGA, BHA, and BHT gave very high protective indices of

TABLE 2

Inhibition of hemoglobin-catalyzed lard oxidation by five commercial antioxidants at 37° C.

Antioxidant	Protective indices		
	1×10^{-3}M Antioxidant	1×10^{-4}M Antioxidant	1×10^{-5}M Antioxidant
Alpha-tocopherol	7.9	1.0	0.3
Phopyl gallate	3.9	1.6	1.5
Nordihydroguaiaretic acid	>72.3	6.1	1.0
Butylated hydroxyanisole	>64.2	15.4	2.6
Butylated hydroxytoluene	>74.3	24.0	1.0

greater than 72, 64, and 74 respectively. At a concentration of 10^{-4}M the differences in protective indices became more marked. At this concentration the effectiveness of these antioxidants decreased in the order of BHT, BHA, NDGA, propyl gallate, and alpha tocopherol with protective indices of 24.0, 15.4, 6.1, 1.6 and 1.0, respectively. The effectiveness of all the antioxidants increased with increasing concentration.

Effect of naturally occurring nitrogenous compounds as inhibitors and synergists. It was our desire in the present work to find nitrogenous compounds capable of inhibiting hematin catalysis in fat oxidations. Compounds were chosen from several groupings: (a) amino acids; (b) nitrogen bases; (c) phospholipids; (d) polypeptides and protein hydrolysates; (e) purines and pyrimidines; and (f) the vitamins. The inhibition of individual compounds within these groups is listed in Table 3.

Fifty percent inhibition was exhibited by 0.5% lecithin and by 0.002 M glutathione. From 20 to 25% inhibition was shown by 0.02 M creatine, 0.05% casein hydrolysate, and 0.02 M adenine sulfate. Ten to 15% inhibition was shown by glycine, histidine hydrochloride, lysine hydrochloride, glycyl glycyl glycine, and guanine hydrochloride. The remainder of the nitrogenous compounds which were tested were either non-effective or slightly prooxidative.

Compounds in Table 3 which gave inhibition were later tested as synergists with 10^{-3} M NDGA on hemoglobin catalyzed lard oxidation. All of these synergists were used in concentrations of 0.04 M except for lecithin and casein hydrolysate, which were used in concentrations of 0.25% and 0.05%, respectively. All were promising except for glutathione which showed a catalytic effect in which the oxygen absorption became about five times that of the control sample at the end of the first hour. Of the previously mentioned synergists, histidine and lysine were studied more thoroughly and are discussed later.

TABLE 3

Inhibitory effects of nitrogenous compounds on lard oxidation catalyzed by 10^{-3} M hemoglobin at 37° C.

Compound	Concentration	% Inhibition
Amino acids		
Arginine	0.02 M	P[1]
Cysteine	0.02 M	0
Glycine	0.02 M	10%
Histidine HCl	0.02 M	10%
Lysine HCl	0.02 M	10%
Tryptophan	0.02 M	0
Nitrogen bases		
Betaine	0.02 M	0
Choline chloride	0.02 M	P
Creatine	0.02 M	20%
Creatinine	0.02 M	P
Phospholipids		
Cephalin	0.05%	0
Cephalin	0.50%	0
Lecithin	0.05%	0
Lecithin	0.50%	50%
Polypeptides and protein hydrolysates		
Casein hydrolysate	0.05%	25%
Glutathione	0.02 M	52%
Glycyl glycyl glycine	0.02 M	10%
Lactalbumin hydrolysate	0.05%	0
Purines and pyrimidines		
Adenine sulfate	0.02 M	25%
Guanine HCl	0.02 M	15%
Ribose nucleic acid	0.02 M	0
Uracil	0.02 M	0
Xanthine	0.02 M	0
Vitamins		
Biotin	0.00001 M	0
Nicotinamide	0.02 M	0
Riboflavin	0.00007 M	0

[1] Prooxidative.

Synergism of amino acids with NDGA. Some of the hemochrome formers have been shown to be effective as inhibitors of hematin-catalyzed fat oxidation *(15, 16)*. Perhaps the hemochrome-forming properties of a compound could be used as a basis for predicting its inhibitory powers as a synergist. To test this possibility lysine, a weak hemochrome former, and histidine, a strong hemochrome former, were used in synergistic combinations with 10^{-4}M NDGA for inhibition of hemoglobin-catalyzed lard oxidation. NDGA at 10^{-3}M and 10^{-5}M was also tried with histidine but no effective synergism resulted. Table 4 shows that the protective indices of either lysine or histidine, when used alone, were about unity, indicating no inhibitory effect. However, when lysine or histidine was used as synergist there was a noticeable increase in the protective indices. At a level of 10^{-3}M synergist the combination of lysine plus NDGA gave a protective index of 9.1 and histidine plus NDGA gave a protective index of 12.2. Increasing the concentration of synergist with NDGA increased the protective index. It is apparent from Table 4 that histidine is a more effective synergist than lysine. However, it cannot yet be generally stated that the stronger hemochrome former is the better synergist because in an experiment using sodium cyanide instead of lysine or histidine with 10^{-4}M NDGA, a negative synergism was exhibited. At 10^{-3} sodium cyanide the combination of cyanide and NDGA gave a protective index of 5.1 whereas cyanide and NDGA gave individual protective indices of 2.9 and 6.8, respectively. Since cyanide, the most powerful hemochrome former studied, did not show a synergistic effect, it appears that further study is necessary with other hemochrome formers before definite conclusions can be drawn.

TABLE 4

Synergism of amino acids with 10^{-4} M NDGA in the inhibition of hemoglobin-catalyzed lard oxidation at 37° C.

Concentration of Synergist	Protective Index					
	NDGA	Lysine	Lysine plus NDGA	NDGA	Histidine	Histidine plus NDGA
None	6.8			6.1		
0.01 M		1.2	14.5		1.0	17.2
0.001 M		1.2	9.1		1.0	12.2
0.0001 M					1.0	10.9

Synergism of ascorbic acid with NDGA. The synergistic effects of several levels of ascorbic acid with 10^{-4}M NDGA were determined on a hemoglobin-catalyzed lard oxidation. This level of NDGA was used because an earlier experiment with histidine had shown that the greatest amount of synergism was expressed at this concentration. The concentrations of ascorbic acid used ranged from 10^{-6}M to 4×10^{-2}M. However, an effective synergism occurred only in the range of 10^{-4}M to 5×10^{-3}M with the maximum effectiveness occurring at the level of 2.5×10^{-3}M ascorbic acid.

The concentrations of 10^{-3}M and 10^{-4}M ascorbic acid were chosen from the lower portion of the effective synergist range for expansion of the studies to propyl gallate, alpha-tocopherol, BHA, and BHT. The effectiveness of these synergistic combinations of phenolic antioxidants with ascorbic acid may be seen in Table 5. Only BHA appeared to be useful at a concentration of 10^{-5}M antioxidant plus 10^{-3}M ascorbic acid. When the amount of phenolic antioxidant was increased to 10^{-4}M, synergism was readily apparent with ascorbic acid in all cases except with BHT, which gave negative synergism. When 10^{-3}M BHT was used with 10^{-4}M ascorbic acid, a protective index of 147.0 was found. A level of 10^{-3}M BHT was also used with 10^{-3}M ascorbic acid, but time limitations (i.e., hrs.) necessitated a termination of the experiment. However, since the previously mentioned cases of ascorbic acid synergism from Table 5 have all required a level of 10^{-3}M ascorbic acid in order to be noticeably effective, we might predict that if this reaction inhibited by 10^{-3}M BHT plus 10^{-3}M ascorbic acid had been allowed to proceed to completion, the protective index would be much

TABLE 5

Synergism of ascorbic acid with various antioxidants for inhibition of hemoglobin-catalyzed lard oxidation at 37° C.

Antioxidant	Ascorbic acid	Protective index		
		Antioxidant concentration		
		10^{-3}M	10^{-4}M	10^{-5}M
	x 10^{-4}M			
Alpha-tocopherol	10	7.2	2.2	0.4
	1	8.4	0.5	0.3
	0	7.9	1.0	0.3
Propyl gallate	10	8.7	4.0	1.4
	1	4.4	1.3	1.1
	0	3.9	1.6	1.5
Nordihydroguaiaretic acid (NDGA)	10	—	44.0	—
	1	—	38.9	—
	0	—	10.6	—
Butylated hydroxyanisole (BHA)	10	>64.2	40.5	4.9
	1	>64.2	16.5	1.4
	0	>64.2	15.4	2.6
Butylated hydroxytoluene (BHT)	10	>69.0	8.1	—
	1	147.0	6.1	1.0
	0	74.3	24.0	1.0

higher. Similarly, the experiment with 10^{-3}M BHA and the two levels of ascorbic acid would probably have greatly surpassed an index of 64.

It is interesting to note that ascorbic acid synergizes with all the antioxidants and that at the level of 10^{-4}M antioxidant, it was best with NDGA.

Multiple synergism of NDGA, ascorbic acid and histidine. Inhibition of hemoglobin-catalyzed lard oxidation was investigated using 10^{-4}M NDGA as primary antioxidant with ascorbic acid and histidine hydrochloride as synergists. Results in Table 6 show that histidine or ascorbic acid alone are of little or no value as inhibitors, regardless of the concentration used. NDGA alone was slightly effective at this concentration with a protective index of 2.7. The addition of 10^{-2}M histidine to the 10^{-4}M NDGA increased the protective index to 6.2. When the multiple synergist, consisting of 10^{-4}M NDGA, 10^{-2}M histidine, and 10^{-2}M ascorbic acid, was used, the inhibitory effect was not increased, but was slightly lowered as shown by the protective index of 5.4. A synergistic effect was not noted in the multiple synergistic system until the concentration of histidine was decreased to 10^{-3}M and 10^{-4}M, at which levels protective indices greater than 84 were expressed. Although this ternary system was highly effective at these levels, it was no better than the binary system containing 10^{-4}M NDGA and 10^{-3}M ascorbic acid which also gave a protective index greater than 84.

NDGA, BHT and ascorbic acid. A ternary system, consisting of two primary antioxidants and one synergist, was also used to inhibit hemoglobin-catalyzed lard oxidation. BHT in concentrations of 10^{-2}M, 10^{-3}M, and 10^{-5}M was used with 10^{-3}M and 10^{-4}M ascorbic acid and 10^{-4}M NDGA. With NDGA and BHT constant, the addition of 10^{-3}M ascorbic acid gave a resultant inhibition greater than when 10^{-4}M ascorbic acid was added. When NDGA and ascorbic acid were held constant, addition of BHT in increasing amounts gave increased synergism. The best combination for multiple synergism of these inhibitors occurred at a level of 10^{-4}M NDGA, 10^{-4}M ascorbic acid, and 10^{-4}M BHT, in a reaction run for 200 hours. Results of the foregoing experiment are shown in Table 6. Notice that 10^{-4}M BHT alone with a protective index of 32.8 is over four times as effective as 10^{-4}M NDGA alone which has a protective index of 6.7. When the two are combined, their synergistic effect is roughly four times the sum of their individual effects. When 10^{-4}M ascorbic acid, which alone has little value, is added to NDGA and BHT, the rapid oxidation of the lard is inhibited for over 200 hours, giving a protective index of 298. Thus, it has been demonstrated that remarkable synergism exists between the antioxidants NDGA and BHT and that the synergism increases tremendously when ascorbic acid is introduced into the system.

TABLE 6

Multiple synergists as inhibitors of hemoglobin-catalyzed lard oxidation at 37° C.

NDGA with ascorbic acid and histidine

Inhibitor	Protective index
10^{-4}M NDGA	2.7
10^{-2}M 10^{-2}M ascorbic acid	1.3, 1.5
10^{-2}M 10^{-2}M 10^{-4}M histidine	1.2, 1.0, 1.0
10^{-4}M NDGA plus 10^{-2}M histidine	6.2
10^{-4}M NDGA plus 10^{-2}M ascorbic acid	>84.0
10^{-4}M NDGA plus 10^{-2}M ascorbic acid plus 10^{-2}M histidine	5.4
10^{-4}M NDGA plus 10^{-2}M ascorbic acid plus 10^{-3}M histidine	>84.0
10^{-4}M NDGA plus 10^{-2}M ascorbic acid plus 10^{-4}M histidine	>84.0

NDGA with ascorbic acid and butylated hydroxytoluene (BHT)

Inhibitor	Protective index
10^{-4}M ascorbic acid	1.0
10^{-4}M NDGA	6.7
10^{-4}M BHT	32.8
10^{-4}M NDGA plus 10^{-4}M BHT	165.6
10^{-4}M NDGA plus 10^{-4}M BHT plus 10^{-4}M ascorbic acid	>298.0

Inhibition of oxidative rancidity in pork, turkey and salmon adipose tissue. When the pork, turkey and salmon adipose tissue developed organoleptic rancidity, peroxide values in the range 9 to 107 developed. Non-rancid tissue had peroxide values of less than 6.

The inhibition of rancidity in terms of days stability is shown in Table 7. The pork, salmon and pork pieces treated with the synergistic mixture had remarkable stability at 0° C. Turkey adipose showed little increase in stability even at the highest concentration of the antioxidants and synergists, but the reason for this is not known.

TABLE 7

Inhibition of oxidative rancidity in pork, turkey, and salmon adipose tissue at 0° C. with multiple synergists

Adipose tissue	Days to turn rancid			
	Control	Propylene glycol only	0.003% NDGA 0.0018% BHA 0.0018% Ascorbic acid	0.01% NDGA 0.02% BHA 0.047% Ascorbic acid
Pork	21	26	>69	>69
Turkey	18	26	26	36
Salmon	18	26	>69	>53
		Propylene glycol only	0.001% NDGA 0.02% BHA 0.0018 Ascorbic acid	0.0018% NDGA 0.0018% BHA 0.0018% Ascorbic acid
Pork pieces		16	>106	>106

DISCUSSION

Hemoglobin, hemin and cytochrome catalyze unsaturated lipid oxidation by a peroxidative mechanism previously described *(12, 16)*. The greater lipid oxidation rates when hemoglobin was the catalyst may be a function of better orientation at the lipid water interface or oxygen transport via oxyhemoglobin. In contrast to the activity pattern in lipid emulsions of hemoglobin > hemin ≅ cytochrome, in colloidal linoleate all 3 catalysts have essentially equal activity *(12)*.

The comparison of antioxidants as inhibitors of hemoglobin catalysis of lard oxidation has revealed that the hindered phenols, BHT and BHA, are much more effective than NDGA, propyl gallate, or alpha-tocopherol in the order given when used without synergist. However, when 10^{-3}M ascorbic acid was used as synergist with 10^{-4}M antioxidant, the order became NDGA, BHA, propyl gallate, alpha-tocopherol, and BHT. Moore and Bickford *(13)* evaluated these antioxidants

in an autocatalyzed homogenous lard system and found that a mere change of antioxidant concentration changed their order of effectiveness. Hence it is difficult to establish a rule as to which antioxidant is more effective if the system is slightly altered.

The search for naturally occurring nitrogenous compounds which would directly inhibit hematin catalysis was not successful. While nitrogenous compounds were ineffective alone, the amino acids were quite effective as synergists. Since inhibition of hematin catalysis through hemochrome formation by a reaction of nitrogenous compounds with the iron in the heme nucleus is a probable mechanism, the synergism of amino acids on the basis of their hemochrome forming ability was examined. Histidine, a stronger hemochrome-former than lysine, gave a greater inhibition than the latter. However, the use of cyanide in the system replacing the amino acid gave an inhibition much less than that found for lysine; this is not in accord with the hypothesis that the best hemochrome formers would be the best inhibitors or synergists. A more thorough study of synergism involving hemochrome formers is needed in order to establish the mechanism of amino acid synergism.

Ascorbic acid has been shown in the present research to be a good synergist with several compounds, both in binary and ternary systems. There are several possible reasons for this synergism. Privett and Quackenbush *(11)* have explained the synergism of ascorbic acid through a mechanism by which the ascorbic acid acts as an inhibitor of alpha-tocopherol, NDGA, and hydroquinone catalysis of peroxide decomposition.

It is more likely that ascorbic acid regenerates any primary phenolic antioxidant that has been oxidized. It may also reduce methemoglobin to hemoglobin. Reduced hemoglobin may be non-catalytic, thus, reducing the amount of catalyst for the initiation of more chain reactions.

The present study shows that the most effective means of inhibiting hematin catalysis is the use of multiple synergists. The combination consisting of BHA, NDGA and ascorbic acid was the most effective whether in model system or actual adipose tissue. The fact that this ternary combination was effective with pork and salmon both in low concentration (0.0018% BHA, 0.003% NDGA, and 0.0018% ascorbic acid) and high concentration (0.02% BHA, 0.01% NDGA, and 0.047% ascorbic acid) gives promise for the application of these antioxidants in protecting all meats. The regulations of the Bureau of Animal Industry *(18)* state that NDGA, alpha-tocopherol, propyl gallate, BHA, and BHT are approved for use in animal and vegetable fat, but that combinations of two or more antioxidants should not exceed a total of 0.02%. The lower level of antioxidant mixture thus falls within the tolerance given, whereas the higher level is 0.01% above this tolerance. The Bureau of Animal Industry limits the use of ascorbic acid to 0.75 oz. per 100 lbs. of meat *(19)*.

For the application of the synergistic antioxidant mixture suggested in this report to the inhibition of oxidative fat rancidity in refrigerated or frozen meat products further evaluation should be made under commercial conditions.

SUMMARY AND CONCLUSIONS

Manometric measurement of the oxidation of lard in aqueous emulsions and catalyzed by hemoglobin allows rapid evaluation of antioxidants and synergists.

On the basis of the results of this research it is doubtful if there can be found nitrogenous inhibitors which inhibit by direct combination with hematin compounds and which are suitable for use in meats. Ot greater practical consideration for inhibiting oxidative rancidity in meats are synergistic mixtures of some of the approved food antioxidants. One such mixture evaluated in this study is that of NDGA, BHA and ascorbic acid.

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Color Changes of Fats Involved in the Frying of a Fritter-Type Batter[a, b]

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(Manuscript received January 27, 1956)

DARKENING OF FATS AND OILS during the process of deep fat frying is a common phenomenon. Porter *et al. (6)* reported that lard used for frying 800 dozen doughnuts had a chocolate color; it was light chocolate after frying 600 dozen. Bates *(1)* commented that the initial color of a frying fat was not indicative of stability; other factors being equal, one shortening tended to darken as much as another. Lowe *et al. (5)* compared the changes in fats after cooking doughnuts or potato chips, and noted that the frying of doughnuts caused greater discoloration of the frying fat than did potato chips. It was observed during several frying studies in this laboratory that the rate and degree of darkening and the development of predominantly yellow or brown tones varied with the type of food being fried. The frying of a fritter-type batter produced a greater degree of darkening of the frying fat than French-fried potatoes *(2)*.

Lantz and Carlin *(4)* used a subjective measurement of color, the Lovibond system, in recording color changes of 3 hydrogenated shortenings and 2 blended fats, each used for 100 hours of frying doughnuts. All fats showed a steady increase in color during the first 50 hours of frying. One hydrogenated shortening increased at a little different rate than the other fats.

The Hunter Color Difference Meter, a tri-stimulus colorimeter, has been used for the objective detection of color differences in foods. Color measurements on this instrument have been made on a number of fruit and vegetable products, including tomato purees *(9)* and tomato juice *(7, 8)* and the browning of frozen peaches *(3)*. Since a Hunter Color Difference Meter was available for use, the color changes of fats used for frying fritters were studied in detail by means of this instrument. The results are reported in this paper.

EXPERIMENTAL PROCEDURE

A fritter-type batter and several modifications of the original fritter mixture were fried in deep fat. The batter contained all-purpose flour, sugar, tartrate baking powder, and salt, sifted together, and added to an egg and milk mixture. This fritter batter is less rich in fat and sugar than a standard doughnut and usually contains added fruit or vegetable when prepared in the home. For the purposes of this study, however, only the batter was fried. Each individually mixed batch yielded 12 fritters, fried in 2 lots of 6 balls each at 190° ± 5° C. for approximately 8 minutes in an electric deep fat fryer of the household type.

The following lards, prepared especially for these experiments, were used for frying: (a) a low temperature, continuous process rendered lard without the addition of an antioxidant; (b) a continuous process lard with 0.05% antioxidant added; (c) a steam rendered lard without addition of antioixidant; and (d) a steam rendered lard with 0.05% antioxidant. The antioxidant in all cases was made up of a mixture of 20% butylated hydroxyanisole, 6% propyl gallate, 4% citric acid and 70% propylene glycol. Frying was also done in a lard obtained from the retail market and in 2 combination shortenings containing re-arranged or "molecular-modified" lard admixed with other fats, an antioxidant mixture, and mono- and diglycerides. The shortenings contained as antioxidants not more than 0.01% nordihydroguaiaretic acid, 0.02% butylated hydroxyanisole and 0.005% citric acid in propylene glycol. Combination shortening I was supplied in 3-pound consumer-sized packages and shortening II in a 25-pound container. Samples of the frying fats were secured at intervals during the frying periods for determination of color change on the Hunter Color Difference Meter.

The Color Difference Meter was standardized with the National Bureau of Standards plate No. 73-311-320 and SKC SBC (White 00). This plate has Hunter values of L, 85.7, a, −1.0, and b, +0.4. Samples were placed in a cylindrical cell 4.5 centimeters high and 6 centimeters in diameter for measurement. The fat was packed to a depth of at least 2.5 centimeters and samples were at room temperature when tested. Care was taken to exclude air in the fat.

Data were recorded in terms of Hunter color values L, indicating visual lightness, a, indicating redness when plus, gray when zero, greenness when minus, and b, indicating yellowness when plus, gray when zero, blueness when minus. The vectoral difference, in NBS units, for each sample as compared to the standard, was calculated from the following formula

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}.$$

RESULTS AND DISCUSSION

Fritters fried in various fats. The data in Table 1 indicate appreciable change in all three of the Hunter scales when fritters were fried in a variety of fats. Changes in L values, representing color lightness, were greatest. This would appear to be the case from observation of photographs of the continuous process lard

TABLE 1
Color change in different fats used for frying a fritter batter

Amount batter fried	Continuous process lard				Continuous process lard with 0.05 per cent antioxidant[1]			
Number of batches[2]	"L"	"a"	"b"	ΔE	"L"	"a"	"b"	ΔE
0	83.6	−2.4	+ 5.8	5.96	83.4	−2.1	+ 6.0	6.15
2	75.5	+1.6	+ 8.3	8.38	74.1	+1.7	+11.1	16.01
5	67.5	+3.4	+11.2	21.62	63.5	+4.3	+12.2	25.69
10	55.3	+4.8	+11.7	32.95	52.3	+5.5	+12.7	36.18
20	37.6	+6.3	+10.3	49.65	33.2	+6.6	+10.8	54.06
	Steam rendered lard				Steam rendered lard with 0.05 per cent antioxidant[1]			
0	75.1	−0.3	+ 7.9	13.00	74.4	−0.4	+ 7.0	13.10
2	69.2	+2.7	+12.3	20.68	68.4	+3.0	+12.1	21.26
5	63.3	+4.4	+12.6	26.07	59.6	+4.8	+13.3	29.69
10	50.4	+5.8	+12.2	37.83	52.4	+5.4	+12.2	35.90
20	30.7	+7.2	+11.0	56.61	29.6	+7.2	+10.8	57.64
	Combination shortening I				Combination shortening II			
0	82.7	−0.8	+ 9.0	9.11	82.7	−1.1	+ 8.3	8.45
2	75.6	+2.5	+12.2	15.92	75.8	+2.0	+12.3	15.77
5	67.2	+4.1	+12.8	22.85	66.8	+4.1	+13.2	23.39
10	53.0	+5.9	+12.6	35.58	53.8	+5.8	+13.7	35.22
20	33.9	+7.0	+10.3	54.22	40.6	+7.3	+13.2	47.61

[1] Propyl gallate, butylated hydroxyanisole, and citric acid in propylene glycol.
[2] Four hundred and ten grams of batter per batch, fried in 12 balls.

[a] Supported in part by the Research Committee of the Graduate School with funds from the Wisconsin Alumni Research Foundation.

[b] Publication approved by the Director of the Wisconsin Agricultural Experiment Station.

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samples used for frying which are shown in Figure 1. The change in lightness (or darkness) was readily noted. Changes in some of the other components of the color, however, could not be so easily detected visually.

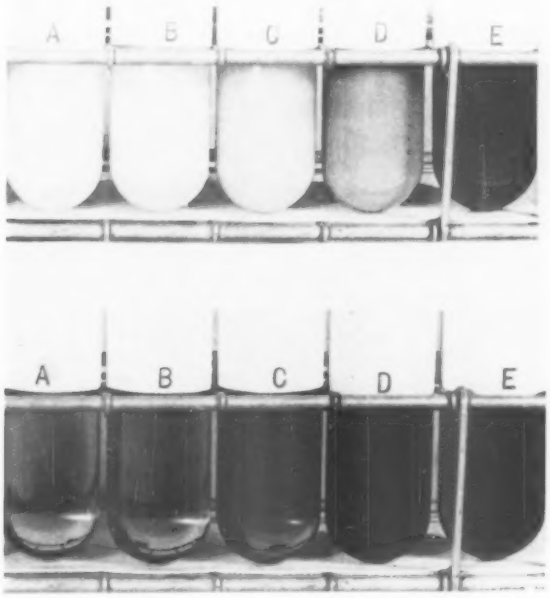

Figure 1. Color of continuous process lard used for frying fritter batter.[4] Upper row: samples at room temperature. Lower row: same samples at 60° C. A. before frying, B. 2 batches, C. 5 batches, D. 10 batches, E. 20 batches of batter fried.

The general trend of changes was similar in all fats tested. A gradual increase in the a scale to plus values indicated a development of red as frying proceeded through 20 batches of fritters, or 5.2 hours of actual frying time. The b scale also increased through the frying of the tenth batch of fritters, or approximately 2.6 hours of frying, after which all fats showed a slight decrease in this scale. This would indicate a general increase in yellowness as the fats were used for frying fritters, but with the development of yellow somewhat retarded toward the end of the frying period. It may be noted that the initial readings of the fats, all related to a white standard, differed. Of the fats studied, the steam-rendered lards gave the lowest readings on the L scale and therefore were the darkest in color, both initially and at the end of the frying period. The b scale readings before frying showed slightly more yellowness in the combination shortenings than in the continuous process lards, with the steam rendered lards giving an intermediate reading.

The same type of color change as discussed for the fats in Table 1 appeared to be present in cottonseed and peanut oils used for frying fritters. However, the initial color of these oils differed greatly from the other fats used, being a deep yellow, and an adequate standard for the Color Difference Meter determinations was not available. The data for these vegetable oils, as measured on the Hunter instrument, were, therefore, not considered valid in this case.

It is apparent that color changes during frying were extremely large for all fats. Samples being tested would, therefore, be more markedly different from the standard as frying proceeded, and the accuracy of the readings on the Color Difference Meter would consequently be reduced. Combining changes of the three scales into one figure, ΔE, gave an indication of general color difference, as shown in Table 1, but a clearer understanding of the changes is possible by consideration of each of the three values for all samples tested. The development of substances responsible for darkening and the nature of these products is not clearly understood.

Modified fritters fried in lard. When fritter modifications were fried in continuous process lard or in lard purchased from the retail market, color changes varied according to the type of fritter fried (Table 2). The change in L values, or lightness, was less in the fat used for frying a flour, sugar, and water batter than for any other mixture fried. With this batter, a and b changes

[4] Permission has been granted to present this photograph here which was previously presented before the American Home Economics Association in June, 1955 (2).

TABLE 2

Color difference in fats[1] as affected by variation in batter ingredients

Amount batter fried	Continuous process lard, Batter modification: Control				No sugar				Flour, sugar, and water			
Number of batches[2]	"L"	"a"	"b"	ΔE	"L"	"a"	"b"	ΔE	"L"	"a"	"b"	ΔE
0	84.3	−2.1	+ 3.1	3.24	84.3	−2.1	+ 3.1	3.24	84.3	−2.1	+ 3.1	3.24
1					78.2	−0.9	+ 7.8	10.54	80.7	−1.3	+ 5.0	6.80
5					65.5	+3.2	+ 9.5	22.55	79.8	−1.1	+ 6.7	8.63
10	42.2	+6.0	+11.2	47.09	52.4	+4.9	+10.8	35.38	76.3	−0.8	+ 9.9	13.37
20	23.4	+6.7	+ 8.5	63.29	36.3	+6.0	+10.9	50.99	72.7	−0.6	+16.6	20.78
	Lard from retail market, Baking powder modification: None				Tartrate				Combination			
0	82.3	−2.5	+ 6.2	6.89	82.3	−2.5	+ 6.2	6.89	82.3	−2.5	+ 6.2	6.89
2	80.5	+0.9	+ 7.3	8.85	71.4	+1.9	+10.2	17.58	73.6	+2.1	+ 9.5	15.45
5	72.4	+2.4	+ 9.0	16.20	59.0	+4.8	+11.2	29.38	55.9	+5.0	+11.6	32.40
10	62.0	+4.1	+12.2	26.96	42.6	+6.7	+11.9	45.27	43.3	+6.4	+11.6	44.47
20	47.5	+6.7	+15.2	41.68	23.0	+7.0	+ 8.6	63.74	21.3	+6.9	+ 8.3	65.36

[1] Both fats contained 0.05 per cent antioxidant which was made up of a mixture of propyl gallate, butylated hydroxyanisole, and citric acid in propylene glycol.

[2] Four hundred and ten grams of batter per batch, fried in 12 balls.

showed a gradual predominance of yellow as the b scale increased, with only a slight increase in the a scale, which approached zero or gray at the end of the frying period. With the control batter, however, which was the same kind of batter fried in various fats reported in Table 1, the increase in redness was considerably greater and the increase in yellow much less marked. The fritters containing no baking powder caused color changes in the fat which were somewhat similar to those produced by the flour, sugar, and water batter but were less pronounced. The increase in yellow was greater in the batter with no sugar than in the control. In general, the most pronounced increase in yellow, the least increase in red, and the greatest maintenance of lightness were found in samples from the frying of batter containing no baking powder.

CONCLUSIONS

Color changes in lards and combination shortenings used for the deep fat frying of a fritter-type batter, measured with the Hunter Color Difference Meter, were similar. The general trend of changes involved a marked decrease in L values, or color lightness, and increases in the a and b scales, showing the development of reds and yellows. Color changes in lards varied according to the composition of the flour mixture fried. Batters without baking powder maintained higher L values but showed greater increases in yellow than other batter modifications. All color darkening was quite easily observed by sight but the values on the Hunter Color Difference Meter gave quantitative measurement for the components of the color, some of which could not be discerned visually.

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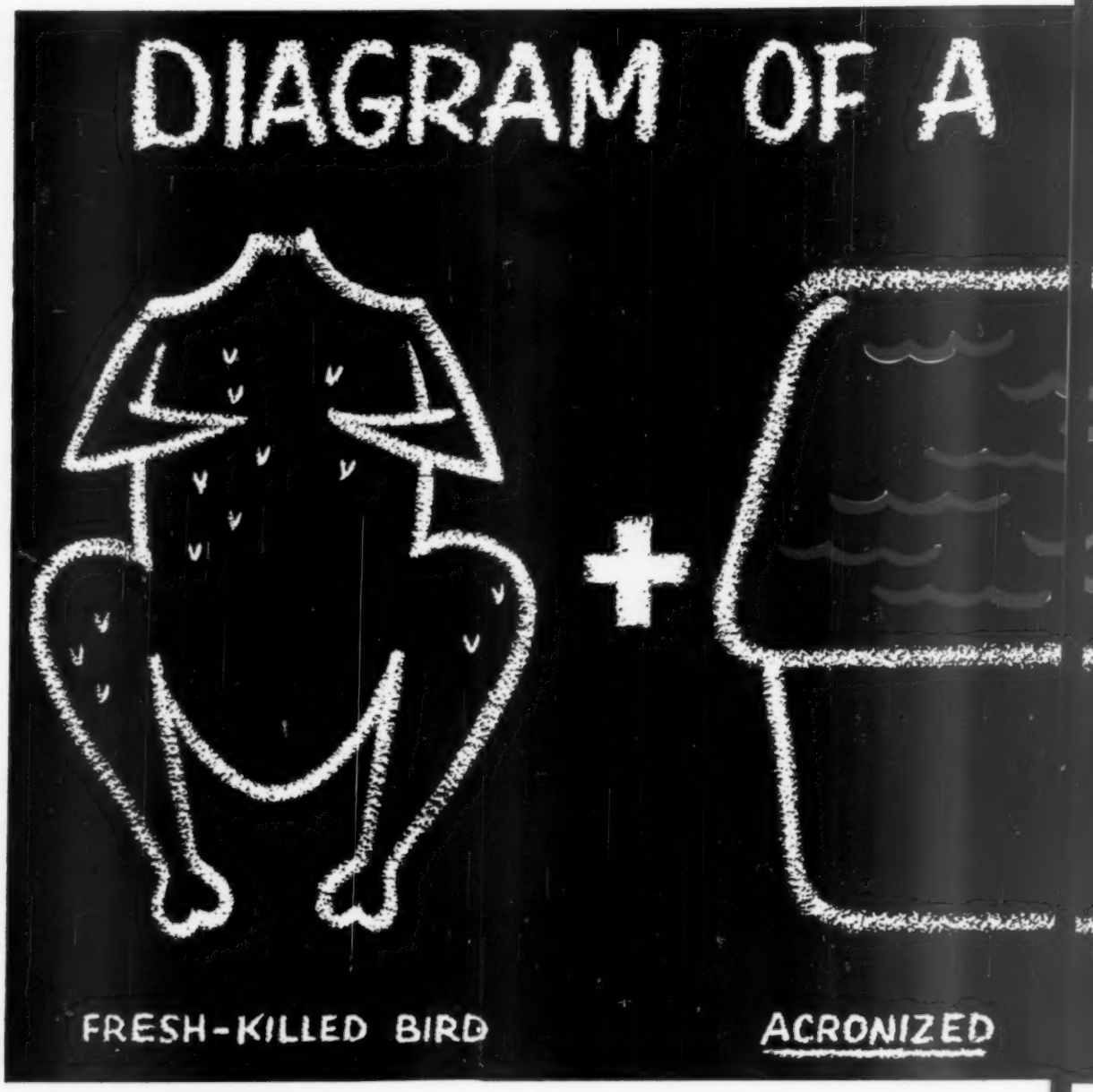

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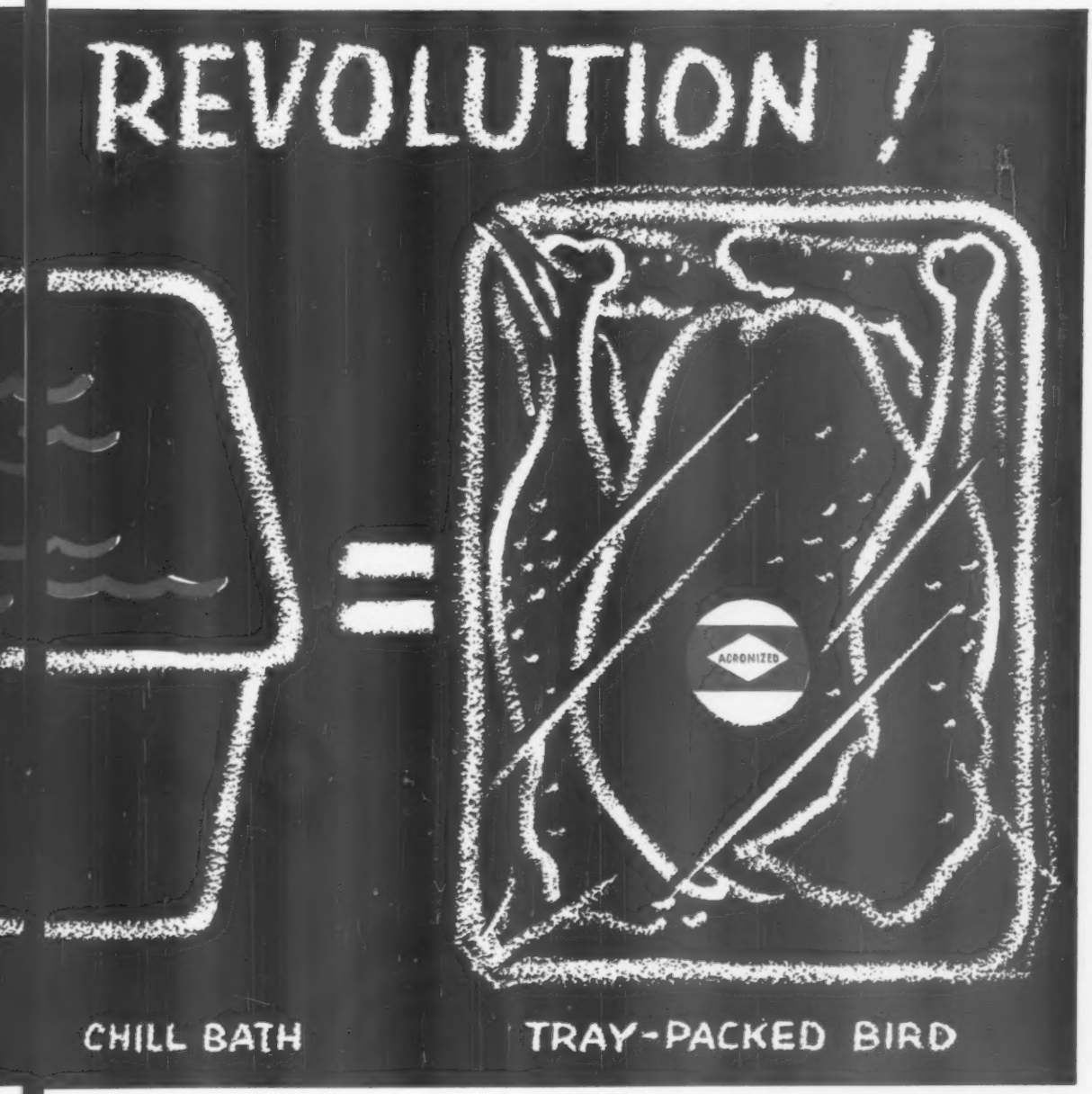

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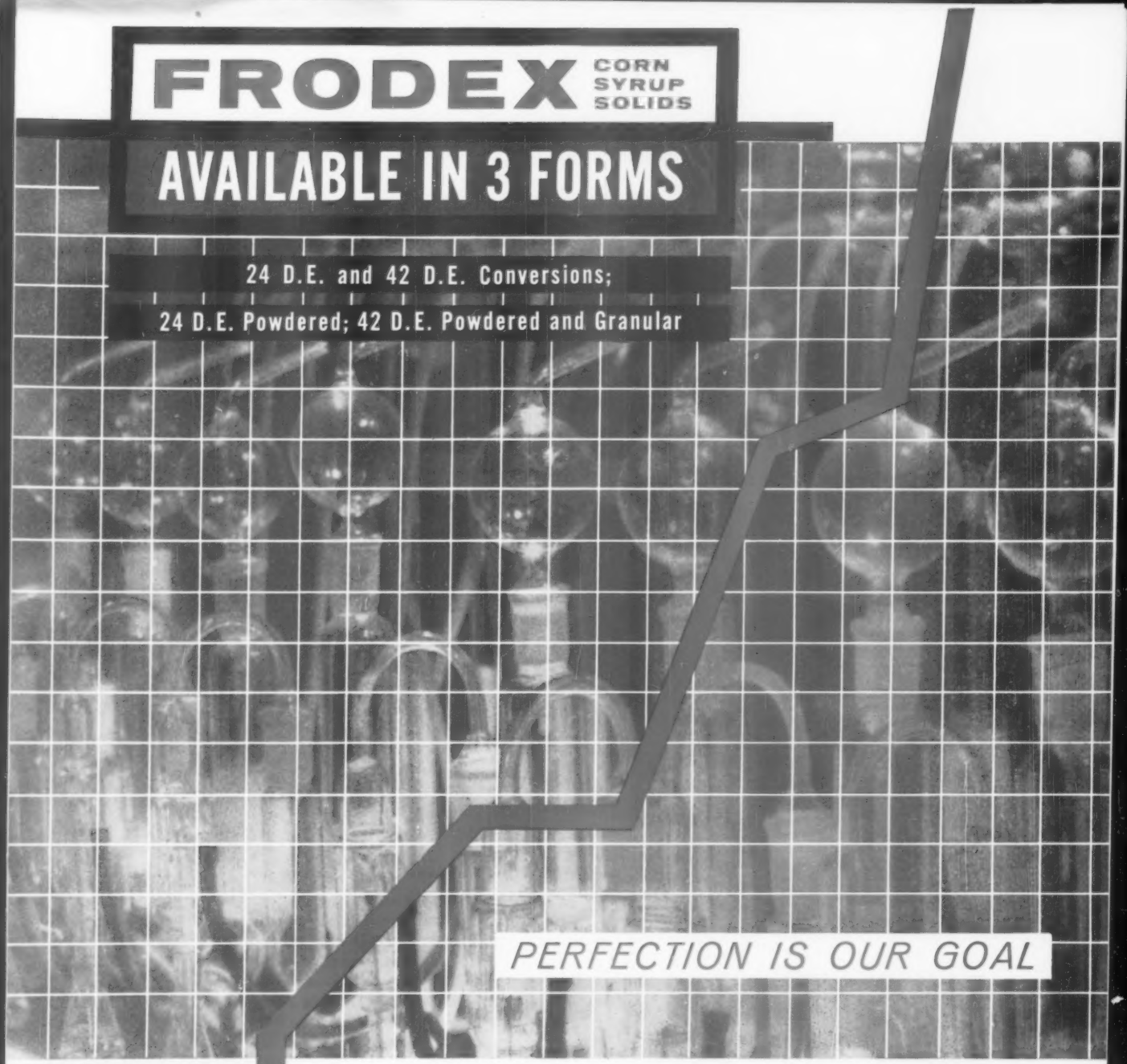

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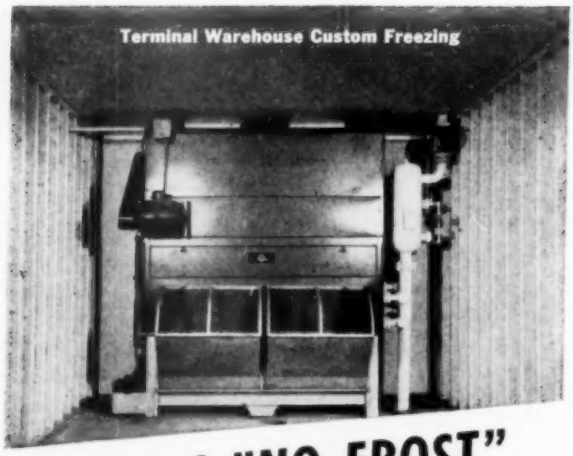

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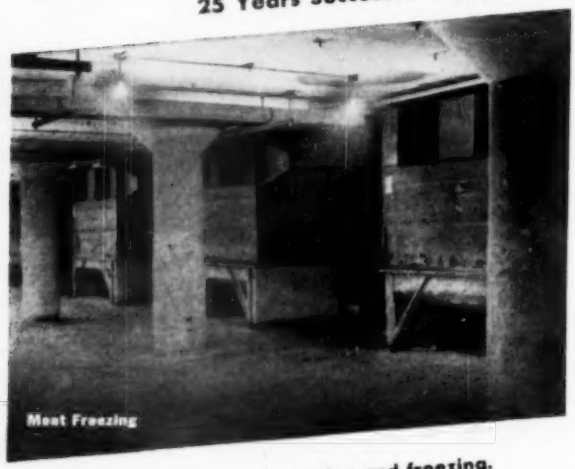

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FOOD INDUSTRY TOPICS

(Continued from page 30 preceding technical papers)

now controlled by the power brakes of measured results it gets or doesn't get. Its claims are power-steered by continuing research into motivation, buying habits, and customer reaction. As a result, the American public is enjoying new safety as well as satisfaction in its ride along the road of progress with advertised products." The article ends with a strong rebuttal of arguments that advertising is wasteful of the public's money. On the contrary, "this nation's epochal economy and prosperity have been built in no small degree upon the demand established by good companies for good products sold by good advertising, developed by good people possessed of good business judgment."

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Climax Molybdenum Company, 500 Fifth Ave., New York 36, N. Y., will sponsor grants-in-aid totaling $26,000 at 15 universities and two independent research foundations for agricultural and biological research on the trace element, molybdenum, during 1956-57. Soil studies will be conducted at the following universities: Connecticut, Florida, Georgia, Indiana, Maine, Michigan, Mississippi, Oregon, Pennsylvania, Rutgers, South Carolina, and Washington. In addition, the Southwest Research Foundation, Houston, Texas, and the Texas Research Foundation, Renner, Texas, will carry out field test work. Biological research is slated for California, Johns Hopkins, and North Carolina. The program was inaugurated in 1950 when the problem of molybdenum-deficient soils in this country first became apparent. Now, about 35 molybdenum-deficient areas have been located in some 20 states, and new ones are being reported regularly. Some dozen crops are being treated commercially with molybdenum chemicals in various sections of the country.

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(Continued on page 48)

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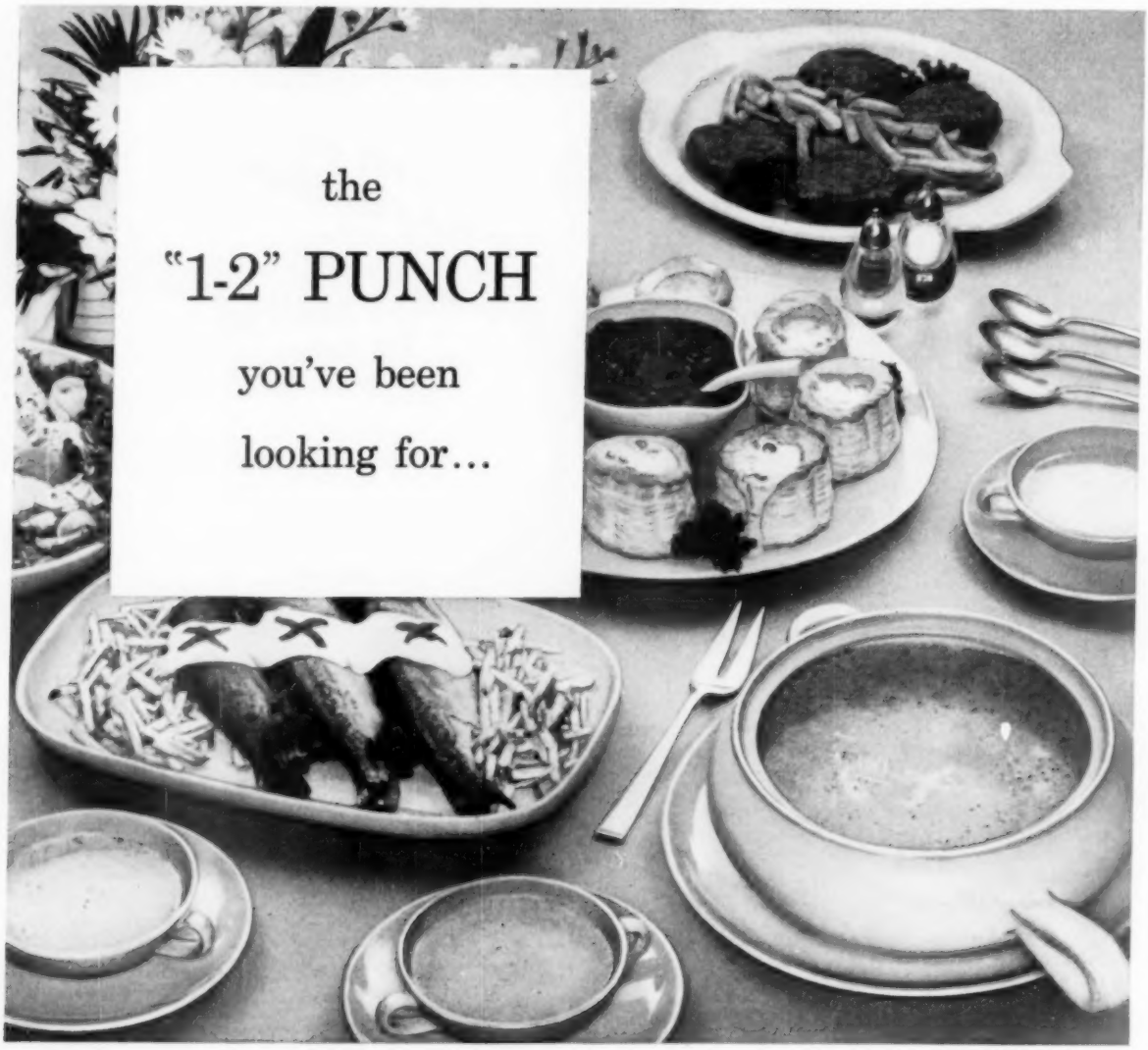

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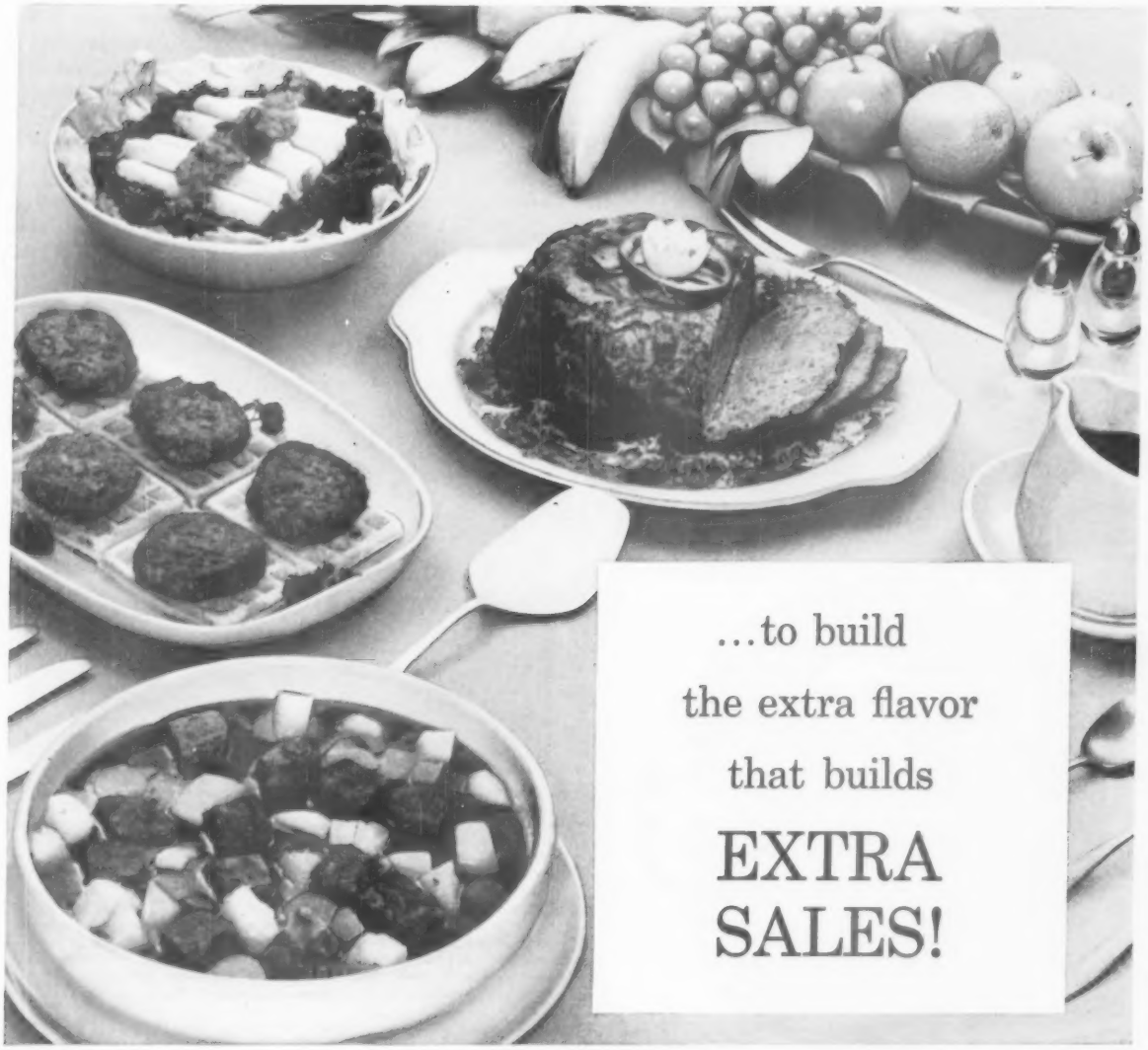

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(Continued from page 44)

lengths ranging from 6′ to 20′. Weight ranges from 145 to 225 pounds. The 10″ wide belt is of non-slipping 3-ply duck and moves at the rate of 65′ per minute. There is a take-up adjustment at each end. The lightweight unit is ideal for use on stairways, as a booster on a gravity conveyor line, stacking, and loading and unloading trucks and rail cars. In any inclined position, the belt does not touch the floor, making possible minimum loading heights. Prices start at $305. The conveyor also is available in a heavier model which can handle fully distributed loads up to 300 pounds.

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To assure trouble-free performance under all loads, Pittsburgh-Erie Saw Corp., 4017-31 Liberty Ave., Pittsburgh 24, Pa., has adopted a heavy-duty solid-hub chopper plate for its meat chopper service. The new Pesco plate is made from a single wear-resistant alloy steel forging. Its heavy, solid hub is designed to absorb the force exerted on the plate's surface in operation. Because its one-piece design prevents meat from working into crevices, the new plate has the advantage of greater sanitation, keeping stoppages for cleaning at a minimum.

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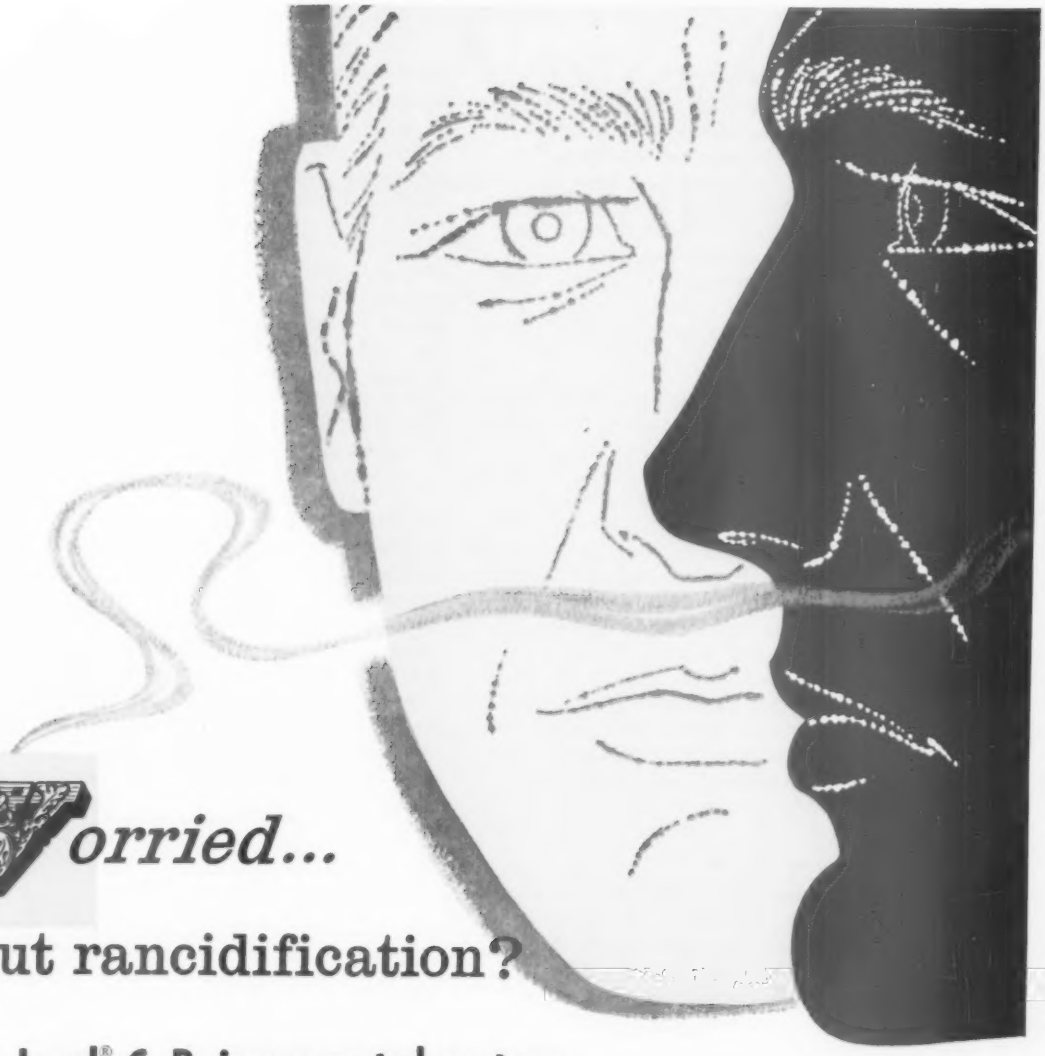
(Continued on page 50)



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SHELL

(Continued from page 48)

proved Class 300 compounds are making possible, for the first time, the molding of silicone rubber parts in the same molds used for organic rubber parts. They also permit specification of closer tolerances than before feasible with silicone rubber. These compounds are the first to achieve their unusually low compression set without toxic additives, permitting use in equipment for food and drug industries. Parts made from the compounds are now being made by leading fabricators of silicone rubber.

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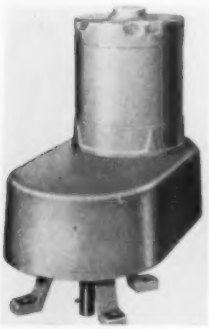

A new Agitator Belt Drive Unit is announced by Little Giant Products, Inc., 1530-1600 N. Adams St., Peoria, Ill. The unit is useful in any application where liquids must be stirred or agitated slowly and positively, and where there must be no possibility of contamination. It is well adapted for bulk milk cooler tanks where rigid sanitary requirements must be met. Motors are available in drip-proof, totally enclosed or explosion-proof types from 1/20 to 1/6 hp. Available to fit all standard agitators, the Little Giant mounts on any bulk milk cooler tank or tanks used for the mixing of other liquids.

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A new, special-purpose ultra-violet lamp for better observation of low-grade fluorescence, particularly in the critical areas of pale blue, light green, and red, has been announced by Black Light Corporation of America, San Gabriel, Calif. This long-wave lamp, BLAK-RAY Model BLF-6, utilizes a special tubular filter to cut down on visible light emission from the "black light" ultra-violet tube; thus less visible light strikes the object being examined. This results in an increase in contrast due to a more complete drop-out of the non-fluorescent background. The unit, operating on 110-125 volt, 50-60 cycle A.C., or on batteries, is especially valuable for sanitation inspection, chromatography, oil analysis. It retails for $22.50.

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Wrap-King's DW series of wrapping machines handles all sizes, shapes, and consistencies of products ranging in size from ½ " to 6½" diameter, and from ¼" to 4" high. With the use of change parts, the machines can be converted within 7 to 10 minutes to accommodate different sizes and shapes of products. Model M Wrap-King automatically feeds, overwraps, labels, and code dates sliced round cold cuts and square luncheon meats at a speed of 60 packages per minute, using cellophane, Pliofilm, or Saran Wrap. Model L lettuce wrapper automatically overwraps 60 heads of lettuce per minute, using cellophane, acetate, or polyethylene. Wrap-King Corp. Berkshire St., Holyoke, Mass., is a subsidiary of Crompton & Knowles Corp., Worcester, Mass., a 120-year-old textile manufacturing concern.

◆ ◆ ◆

"Cut-Rite"—**a new composition cutting board** approved by the Meat Inspection Branch of USDA and designed for boning, chopping, slicing, cleaning, and dicing operations — is offered by Park Rubber Co., Inc., Lake Zurich, Ill. The board will not crack, split, or chip out, will not impart odors and tastes to food, and is easy to clean. It is dense and does not absorb liquids or food particles. It assures longer sharpness to knives. Both sides of "Cut-Rite" may be used.

◆ ◆ ◆

Glengarry Processes, Inc., Bay Shore, N. Y., is introducing its new model Heavi-Weigh—used for net weighing a wide variety of dry materials over a weight range of 5 to 100 pounds. Low cost and simple operation make it ideal for simple filling of containers or automatic batching operations involving a series of machines and electronic program controls. In the food industry, the unit can be used for controlling the proportions of various ingredients in mixing and blending processes. Used in this way, Heavi-Weigh units are hooked up in batteries, with each machine controlled to deposit a predetermined amount of any one ingredient in the mix.

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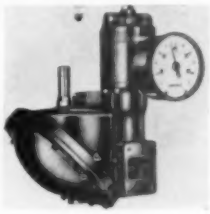

The new Metagraphic Absolute Pressure Transmitter, announced by The Bristol Co., Waterbury 20, Conn., will measure pressures in ranges from 0-5 mm. Hg to 0-760 mm. Hg, and transmit the measurement as a 3-15 p.s.i. pneumatic signal to an automatic controller or receiver. A full line of indicating and recording receivers and automatic controllers also is offered.

◆ ◆ ◆

Two new nontoxic stabilizers, developed and patented by Ferro Chemical Co., a subsidiary of Ferro Corp., 4150 E. 56th St., Cleveland 5, O., have been approved by FDA. They are reportedly the first nontoxic high-temperature resistant stabilizers to be cleared for use in vinyl food wrapping. Called nontoxic 707X and nontoxic 760X, the products will prevent discoloration of vinyl films by hydrochloric acid released during processing of the resin into film (at 360° F.).

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A new means for making rapid tests on tin, nickel, and chromium plating for pores is provided by Detect-O-Pore Test Paper. For use, this test paper is moistened with buffer solution made with a buffer powder furnished and then pressed down on the surface to be tested. Pores are shown by dark spots that develop on the paper. The paper also can be used to indicate the

(Continued on page 52)

THE Sealva STORY OF "Sealed-In" Flavors

Some years ago, van Ameringen-Haebler, Inc. developed and introduced SEALVA Flavors, the first truly hermetically "sealed-in" high quality dry flavors. This new technique in flavor-making was immediately recognized and enthusiastically accepted by the food industry.

Since those early days, continuing improvements in sealing agents and drying techniques plus the basic superiority in the quality of the natural or imitation flavors themselves, have combined to maintain SEALVA's place as the ultimate in fully protected quality flavors.

What can SEALVA do for your product?

The adoption of SEALVA Flavors makes possible the use of absolute top quality flavor in dry mixes, because the finest of flavors are fully protected in their powdered form against the ravages of deterioration caused by evaporation, oxidation, extended shelf-life, and they are practically impervious to chemical reaction with other ingredients in a mix or compound.

Where can SEALVA Flavors be used to advantage?

SEALVA Flavors are ideal in any relatively dry, powdered, grained, or flaked mixture to insure inert flavor retention in such products as cake mixes, gelatin desserts, cereals, drink powders, pudding mixes, dairy mixes, ice cream mixes, candies (pressed wafer), pharmaceuticals, proprietaries, oil emulsions, etc.

For better flavor we ask you to investigate SEALVA Flavors before you make your final decision on this most important ingredient.

We are prepared to give you suggestions as to the methods of readily evaluating "sealed-in" flavors for your particular product and also will be happy to assist with technical recommendations for the application of SEALVA Flavors to improve your product. Literature and adequate samples are available.

Alva FLAVORS

VAN AMERINGEN-HAEBLER, INC.
521 WEST 57th STREET, NEW YORK 19, NEW YORK

SEE US AT THE I. F. T. MEETING IN ST. LOUIS — BOOTH NO. 58

(Continued from page 50)

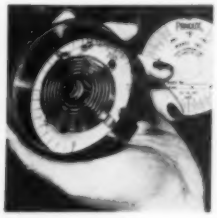
metal under-plating, pin holes in enamel or other protective coating over the metal, and minute rust spots on stainless steel. Furnished in strips 50' long by ½" wide in an opaque plastic dispenser. Available from R. P. Cargille Laboratories, Inc., 117 Liberty St., New York 6, N. Y.

◆ ◆ ◆

A new industrial process refractometer for continuous monitoring of process streams is being manufactured by Barnes Engineering Co., Stamford, Conn. The instrument continuously measures the difference in refractive index between a flowing liquid sample and a reference liquid—the fastest and surest way of determining and controlling the purity of a flowing process stream. Formerly, refractive index measurements were done in a laboratory on a small sample brought from the plant. The unit features a sealed optical system, photocell detection, temperature compensation, and a null balancing system for maximum accuracy. It is also explosion-proofed, the sample cell is readily accessible, and results may be read directly from a dial or a remotely located recorder. Available in three models with ranges of limiting sensitivities covering 0.0001, 0.00001, and 0.000002. Accuracy is better than ± ½%.

◆ ◆ ◆

The Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif., announces a new low-cost Recording Maximum-Minimum Thermometer. The instrument measures ambient temperature and records both the lowest and highest values over any given time period. It features a replaceable paper chart on which a permanent record of the temperature excursion is recorded. The chart can quickly be replaced and filed for future reference. The thermometer comes in two ranges — PANDUX Model 581-F for 50° F. to 250° F., and PANDUX Model 581-C for —50° C. to 100° C. Both are priced at $19.50 each.



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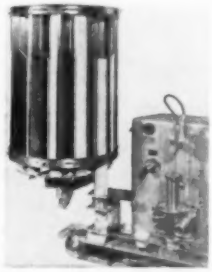
An improved waterproofing material that sets in 5 minutes or less and bonds perfectly to concrete or other masonry walls or floors to eliminate dampness or active water leakage is offered by Maintenance Engineering Co., 16 W. Johnson St., Philadelphia 44, Pa. Called Meco Sealtite, it makes waterproofing inexpensive, can be applied quickly and easily, and will permanently seal masonry walls against hydrostatic pressure. Because of Sealtite's excellent bonding qualities and quick-setting ability, the use of forms and other braces can almost always be eliminated. The substance also makes concrete resistant to oil, grease, and acid. It is supplied in liquid form and mixed with Portland cement for severe conditions, or with Portland cement and sand for ordinary conditions.

◆ ◆ ◆

An actual market test of a new product made from Maine potatoes will be made soon, according to a joint announcement by the Maine Potato Commission, the Maine Department of Agriculture, the Maine Agricultural Experiment Station, and the Eastern Utilization Research Branch, Agricultural Research Service, and the Market Development Branch, Agricultural Marketing Service, USDA. The new product will be known as potato flakes. The addition of water and milk will reconstitute potato flakes to make a delicious mashed potato. The method of producing potato flakes was developed by the Eastern Utilization Research Branch Laboratories in Philadelphia.

◆ ◆ ◆

The Model 365 Rotary Dispenser, announced by Anderson Bros. Mfg. Co., Rockford, Ill., features a 12-column hopper capacity of more than 600 quart size, 600 pint, or 1000 3½ ounce nesting-type cups. Outstanding advantage of this new equipment is that it relieves the operator of the responsibility of keeping a single dispenser filled to keep pace with the fast cup-per-minute speed of present-day modern filling machines. The unit can be mounted directly onto the Anderson Model 341 Synchro-Filler; or furnished with a special stand for attaching to and operating in conjunction with Anderson Models 34C, 34E, and 34F. It also can be used for dispensing 16-ounce cups (or smaller) to the larger Model 34F-20.



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The first flow alarm to combine low cost with vibration-proof operation is announced by Fischer & Porter Co., 553 Jacksonville Rd., Hatboro, Pa. Known as the F&P Ratolarm, it uses two snap-action electrical contacts, hermetically sealed in a glass tube, which are drawn together to set off the alarm by passage of a magnetic float extension rod. The switch can be positioned in the mounting frame either above or below the magnet in the float extension rod to give a signal for either high or low limits of flow. One switch can be set above and another below the magnet to give high and low alarms. Multiple alarms may be incorporated for special applications. Although used most often for flow applications, the new vibration-proof switch can be used for alarms in the measurement of any variable capable of positioning the extension rod, such as liquid level, temperature, or pressure.

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A new type removable valve for milk holding and storage tanks has been incorporated on all its tanks by Walker Stainless Equipment Co., New Lisbon, Wis. Designed particularly for speedy, easy removal, this

(Continued on page 56)

Morton Salt Company's new million dollar laboratory at Woodstock, Illinois, is at the service of the food industry to help you solve any problem relating to salt. For example, here's . . .

How Morton helped kraut packers make a better product

Here's a sauerkraut packer using the plastic enclosed end point testing colors in Morton's waterproof booklet to determine the percent of salt in a kraut sample.

Salting sauerkraut correctly—to produce uniform high quality—presents two important problems to kraut packers.

1 Kraut packers (like other canners and food packers) have the problem of using the right amount of salt. The Morton Salt Company helped solve this problem with an easy-to-use booklet that shows you how to test kraut for salt content.

Morton's waterproof booklet, "Better Sauerkraut through effective use of salt," comes with plastic enclosed end point testing colors, and contains complete data on when and how to test salt content.

2 Kraut packers also face the problem of using the right type of salt for better flavor control. Morton helped solve this problem with Morton '999' Salt.

'999' is a high purity, low cost salt which contains 99.9% clean, pure sodium chloride; exceptionally low in the objectionable trace metals, copper and iron. '999' is an evaporated granulated salt that won't break up in shipment and will dissolve uniformly in an average time of about six minutes (not too fast or too slow). Morton '999' Salt has a practically constant weight per volume and is easily and efficiently dispensed by hand or machine.

How Morton can help you make a better product

Chances are Morton can help you turn out a better product for less money if you use salt for canning, packing or processing any food product. For Morton makes many grades of salt for the food industry, and only Morton has 9 strategically located plants to serve you. We offer fast delivery from a bag to a trainload at favorable prices and freight, *anywhere* in the country.

What's more, one of Morton's Food Technologists can assist you with on-the-spot help with any problem you have pertaining to salt. And he's backed by the services of chemists and salt scientists at Morton's ultra-modern research laboratory.

☐ Please send me your free booklet:* "Better Sauerkraut through effective use of salt."

☐ I am not a kraut packer but would like more information on how Morton can help me:

Name_____

Title_____

Company_____

Street_____

City_____ Zone_____ State_____

*Glassware and chemicals necessary for testing sauerkraut salt content may be obtained at a nominal fee from the Natl. Kraut Packers Assn.

MORTON SALT COMPANY
INDUSTRIAL DIVISION
Dept. FT-6, 120 So. La Salle Street,
Chicago 3, Illinois

Question . . .

Three of the many groups of foods and beverages that are increasing sales with Pfizer vitamin fortification and enrichment:

● You can give carbonated beverages health appeal for just a fraction of a cent per bottle. That's all Pfizer vitamin-fortification costs. Bottlers are already using Vitamins B_1 and C to boost sales to today's vitamin-conscious public. Vitamin B_{12}, a factor in child growth, is also being considered.

● It's a smart sales move to enrich flour, macaroni, corn meal and similar products with Pfizer BI-CAP® enrichment concentrates. They give such products more food value. Let Pfizer show you how BI-CAP can add sales appeal to your product.

● To fortify your sales position in the canned juice, concentrate and fruit "ade" market, fortify these products with Pfizer vitamins. "Vitamin Fortified" on your label is a strong sales inducement. What's more, your vitamin content is standardized to offset processing losses and seasonal variations.

What's the most powerful appeal to the food shopper?

Answer . . . Her family's health!

Here's how to put it in and on your package!

● There's something very basic about the grocery business that's so simple and true that it's often overlooked. More vital to the *permanent sales position* of your food product than all the temporary give-away promotions is *the fundamental desire of every homemaker to provide her family with the maximum in health-giving nourishment.* That's why Pfizer's vitamin fortification and enrichment program fits in so well with any contemplated improvements in your product. Your Pfizer sales representative is prepared to give you full details on how Pfizer vitamins can powerfully increase your product's sales potential. Remember that Pfizer has been a major vitamin research and production center since the first vitamin was commercially produced.

Manufacturing Chemists for Over 100 Years **Pfizer**

CHAS. PFIZER & CO., INC.

Chemical Sales Division

630 Flushing Ave., Brooklyn 6, N. Y.

Branch Offices: Chicago, Ill.; San Francisco, Calif.; Vernon, Calif.; Atlanta, Ga.

(Continued from page 52)

new "Y" type valve simplifies and encourages thorough daily cleaning. The valve can be used to throttle the flow of milk or, by means of an adjustable plug assembly, as a fast-acting valve. There are no tapers to score and gall as in conventional plug type valves.

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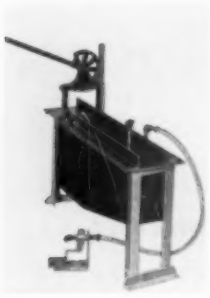
A new can opener-rinser that opens, completely drains, and rinses up to six No. 10 cans per minute has been introduced by F. H. Langsenkamp Co., 235 E. South St., Indianapolis 25, Ind. The new HP Can Opener Rinser requires just one operator, though it reportedly clears cans approximately twice as fast as any other hand-powered opener yet developed. A unique pyramid-shaped bit opens four triangular flaps in the bottom of the can with a pierce-and-pull motion that positively eliminates can slivers getting in the product. Three-inch opening permits drainage of all types of concentrates; semi-solid and viscous products like sirup, pumpkin, and tomato paste; and whole, sliced, or diced fruits and vegetables. All parts that come in contact with product are stainless steel, preventing corrosion from acid base products. Unit is 24" high, 38" long, and 13¼" wide, with a domestic shipping weight of 200 pounds. Manufactured to accommodate No. 10 size cans; No. 12 and other popular sizes on request.



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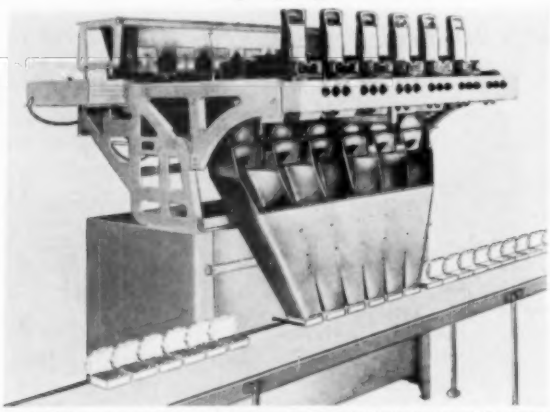

Addition of a full line of Automatic New Weight Scale Units to its family of packaging machinery is announced by Hayssen Mfg. Co., Sheboygan, Wis. The units are available in 2, 3, 4, 5, or 6 scales, and feature an exclusive Triple-Vibrator Feed to give the most even distribution of products from feed to scale. Exact Weight Scales provide tolerances to 1/64 ounce in small products, and to one piece plus in larger items. This is the only full line of scales with check weight indicators. All parts in contact with products are of stainless steel or aluminum. The units are readily adaptable from one product to another, and from hand to automatic conveyor operation.

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A new tray has been developed by Molded Fiber Glass Tray Co., Linesville, Pa., for use in handling or storing candy and other foods. The tray, No. 472, will nest and stack, and is usable on production lines, in storage, or for shipping. Made of fiber glass and polyester resins, and harder than steel on a strength-weight basis, the tray will not bend, dent, warp, or splinter. Available in a variety of attractive colors, it measures 11¾" by 18¾" by 1½".

◆ ◆ ◆

A new line of cooling and conveying systems, to meet the increasing demand for cooling powdered products before packaging, has been announced by Henszey Co., Watertown, Wis. Designed as a simple, compact pneumatic system, it can reduce product temperature to 100° F. or lower. The Henszey system —available as a packaged unit for easy installation— is furnished with a combination filtering and cooling section, and will operate either with a refrigerant or with cold water. Each system is designed and engineered to meet any particular cooling requirements desired and is then fabricated as a package. Fabricated from either mild steel or stainless steel, the systems are available in sizes up to 3000-pound capacity per hour.

◆ ◆ ◆

A new, rigid aluminum foil container has increased fish stick sales for Booth Fisheries by 25% to 100% over those of their old package. Designed by Ekco-Alcoa Containers Inc., it features a ridged bottom (patent pending) that offers the ultimate in consumer convenience. The housewife simply places the container in the oven and browns the fish sticks until ready to serve— in the same container. The ridged bottom prevents burning and sticking, and the air circulating between the ridges insures that heating and browning will be even. Other advantages offered by this new package include a vertical flange rim for easy, automatic closure; paperboard cover offering a large display area for a color vignette of the product; and excellent stacking characteristics. For information contact Mr. Bruce C. Davey, Ekco-Alcoa Containers Inc., 1900 N. River Rd., River Grove, Ill.

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Surety Rubber Co., Carrollton, O., offers a new tractor-tread glove for use of canners and others who must handle wet, slippery materials. Made of natural latex, and with fingers curved for comfort, the gloves are made in gauntlet style only, and in small, medium, and larger sizes. The firm also announces a new rough-finish coated fabric glove designed to provide a positive grip and withstand oils, acids, and solvents. They are available with coated palm and knit wrist, or fully coated with knit wrist, 12" gauntlet or safety cuff. Women's sizes with coated palm are furnished with knit wrist only.

. . . *the literary corner*

"The House of Magnus," a periodical available in three editions devoted to the interests of the drug and cosmetic industry, food industry, and chemical specialties and related industries, is announced by Mag-

(Continued on page 58)

If your customers gave your products a "bug count"

These Petrie dishes give a graphic demonstration of the high degree of spore and yeast removal that can be achieved with Celite filtration.

CELITE FILTRATION removes spores and yeast plus all suspended impurities

How can you be sure that your products are at their very best when they go into the laboratory of an important customer or prospect? One good way is to use the most thorough method of clarification available. That's Celite* diatomite filtration which gives you a filter cake hundreds of times finer than the finest wire mesh. It not only removes suspended impurities, but polishes filtrates to a brilliant sparkling clarity.

Celite is as economical as it is thorough. Only small amounts are required to keep the filter cake open. Fastest flow rates are obtained from the 2,500,000 filter channels in every square inch. And Celite can be used with almost any filter. Automatic operation eliminates the need for costly skilled labor.

Celite is being used successfully today for filtering sugar, beer, syrups, jellies, cooking oils and fats and many other products which at some stage are in a liquid state. Perhaps it offers advantages for your processes too. Write for full facts today.

For further information on Celite filtration for your products write to Johns-Manville, Box 60, New York 16, N. Y. In Canada, address 565 Lakeshore Rd. E., Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products

Johns-Manville CELITE FILTER AIDS

MULTI-POWER
HARD WATER CLEANER

Ideal for Cans Vats Tanks Pipes Fittings

Klenzade "Multi-Power" is a top quality cleaner specifically designed for hard water areas.

POWERFUL DETERGENCY
. . . rapid soil penetration and emulsification.

HIGH SEQUESTERING POWER
. . . keeps water-hardness minerals in suspension . . . no water spotting.

BALANCED ALKALINITY
. . . alkalinity is buffered to maintain constant alkaline cleaning power.

CORROSION CONTROL
. . . the ideal cleaner where steel and iron parts are included in daily clean-up.

100% ACTIVE INGREDIENTS
. . . no inert fillers or carriers. Every ounce does its full duty.

EXCELLENT WATER CONDITIONER
. . . designed for use in hardest of waters . . . up to 50 grs. per gallon hardness.

Prevent waste and high cost of over-use of ineffective cleaners, by starting now with Klenzade Multi-Power . . . "a little does a lot."

"There's a Klenzade Man Near You"
"FIRST IN CLEANING CHEMICALS"

KLENZADE **KLENZADE PRODUCTS, INC.**
BELOIT, WISCONSIN

(Continued from page 56)

nus, Mabee & Reynard, Inc., 16 Desbrosses St., New York 13, N. Y. The publication contains current news items, interesting feature articles and editorials, and valuable information about applications of MM&R products to assist customers in increasing the salability of their products. Anyone who would like to be placed on the mailing list, without cost, should address the firm's Advertising Department.

The April-August, 1956, edition of the same company's king-size catalog contains up-to-the-minute information about flavors and fragrances for more than 80 industries.

◆ ◆ ◆

At the start of its second half-century in the packaging field, Continental Can Co., Inc., 100 E. 42nd St., New York 17, N. Y., has made available a set of revised company Fact Sheets which point out that Continental today is one of the world's largest producers of metal cans and crown caps, the largest producer of fiber drums, and a leading manufacturer of paper cups and containers, paper bags, flexible packaging, steel pails and drums, plastic bottles, and household wares.

◆ ◆ ◆

The Quartermaster Food and Container Institute for the Armed Forces, Chicago, has supplemented its bibliographic series on radiation sterilization of foods with two new volumes just released to industry through Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Earlier volumes in the series were released through OTS last year. These publications were prepared to keep researchers abreast of the rapidly growing literature on the effects of ionizing radiation in the treatment for extended storage life of meats, dairy products, vegetables and flour. Volumes just released are PB 111636S, *Bibliography on Ionizing Radiations, Supplements No. I and II*, Aug. 1955, 537 pages, $11; and PB 111637S, *Subject Index on Ionizing Radiations, Supplements No. I and II*, Aug. 1955, 161 pages, $4.65. Earlier volumes in the series, also available from OTS, are: PB 111634, *Radiation Sterilization—Review of Literature in Selected Fields*, Feb. 1955, 77 pages, $2. This publication contains articles written by radiation sterilization project contractors reviewing the progress of research in the very important fields of proteins, lipids, carbohydrates, meats, vitamins, and enzymes.

◆ ◆ ◆

"Lemon—A Diversity of Uses," is the subject that occupies the attention of *The Givaudan Flavorist*, Number 2, 1956, published by Givaudan Flavors, Inc., 330 W. 42nd St., New York 36, N. Y.

◆ ◆ ◆

A key to candy literature published in trade and technical journals during the 10 years, 1944-54, now is available from Southern Utilization Research Branch of the Agricultural Research Service, USDA, 1100 Robert E. Lee Blvd., New Orleans 19, La. It lists 1466 articles and patents, covering such subjects as manufacturing, merchandising, technology, plant efficiency, and packaging. Author, title, and reference are given, and in most cases a brief abstract of the subject matter is included. The various references

(Continued on page 62)

are classified in a subject index. Single copies of *Candy Bibliography*, a paper-bound book of 1140 pages, may be obtained without cost.

Also available from the same address is the reprint entitled "Quantitative Determination of the Amino Acids of Sugar Cane Juice."

◆ ◆ ◆

Fermcozyme—an enzyme system for stabilizing soft drinks, and thus blocking the corrosive process leading to can failures—is described in a bulletin available from Fermco Chemicals, Inc., 4941 S. Racine Ave., Chicago 9, Ill.

◆ ◆ ◆

A 45-page booklet covering the composition, sources, reactions, handling, and tests for fatty acids is available on request from Armour Chemical Division, Armour & Co., 1355 W. 31st St., Chicago 9, Ill.

◆ ◆ ◆

The latest Fritzsche price list, 12 pages, is available to those whose purchases are in wholesale quantities. Write Fritzsche Brothers, Inc., 76 Ninth Ave., New York 11, N. Y.

◆ ◆ ◆

Niagara Blower Company Bulletin No. 130, "Sectional Aeropass Condenser," 4 pages, shows benefits of new, sectional-design refrigeration condensers for 100 to 240 tons refrigeration capacity, and explains their functions with diagrams and installation photographs. The firm's address is 405 Lexington Ave., New York 17, N. Y.

◆ ◆ ◆

Now available is the second of a series of Aerosol Bulletins for the Dodge & Olcott, Inc. Aerosol Testing Laboratories. Called "Fragrances for Aerosol Space Deodorants," the new folder discusses the growth of this particular segment of the aerosol field, and the current application of this medium for dispensing room deodorants. D&O is located at 180 Varick St., New York 14, N. Y.

◆ ◆ ◆

The advantages of mechanized cleaning methods are described in "Mechanized Cleaning Gives You the Most for Your Cleaning Dollar," published by Oakite Products, Inc., 157 Rector St., New York 6, N. Y. Also available from the firm is a folder, "Everything for Good and Economical Bottle Washing," which considers selection of the proper bottle washing compound to fit the plant's individual needs.

◆ ◆ ◆

The Flavor Division of Syntomatic Corp., 114 E. 32nd St., New York 16, N. Y., announces distribution of its new Flavor Catalog. Data on use of the various flavors described are given as well as suggested proportions to be employed. Make request on company letterhead.

◆ ◆ ◆

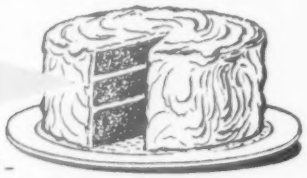
FLOURISH, a waxless, slip-resistant floor coating claimed to be even more foot-sure in wet weather, is described in a 4-page brochure available from U. S. Sanitary Specialties Corp., 1001 S. California Ave., Chicago 12, Ill.

◆ ◆ ◆

The Gaulin Laboratory Homogenizer, specially designed for research, pilot plant, or limited production operations, is covered in a 4-page folder LH-55, released by the Manton-Gaulin Mfg. Co., 44 Garden St.,

FINE FLAVOR

CAKES

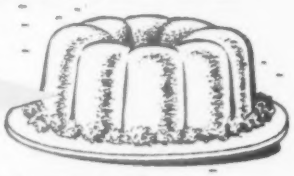


FORMULATIONS

PIE FILLINGS

FOR THE FOOD

GELATINS



INDUSTRY.....

PUDDINGS

FRIES & FRIES

flavors

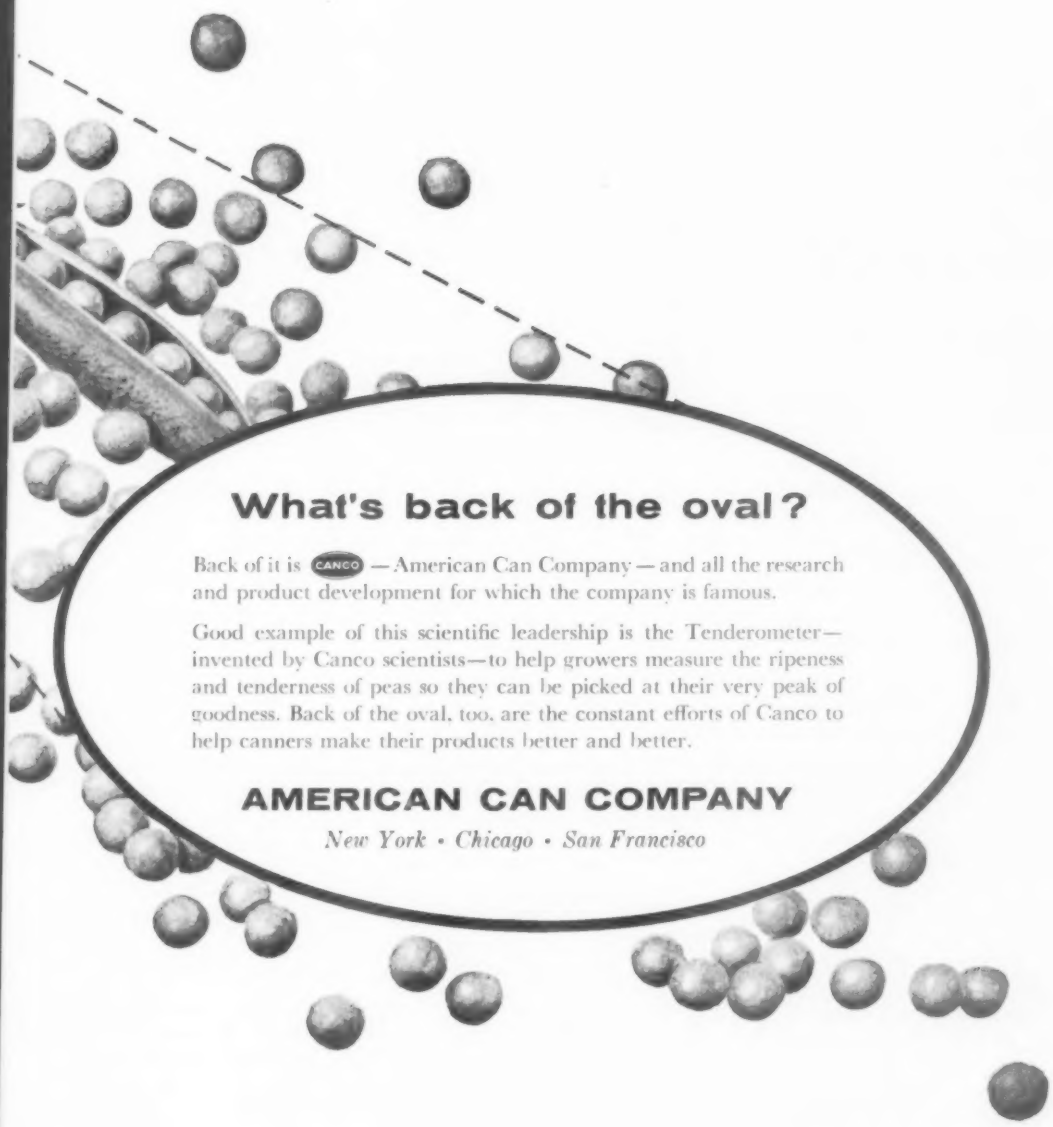
Developing new and distinctive flavors or supplying established ones are equally important at Fries and Fries.

Our modern flavor laboratories are staffed with highly skilled chemists and technicians who have helped perfect the flavorings of many fine products found on every supermarket shelf.

Your inquiry will be given prompt attention and treated in strict confidence.

MANUFACTURING CHEMISTS
FRIES & FRIES
INC.
CINCINNATI
U.S.A.

NEW YORK • 418 E. 91st St. • SA 2-2260
CINCINNATI • 110 E. 70th St. • VA 1-7200



What's back of the oval?

Back of it is CANCO — American Can Company — and all the research and product development for which the company is famous.

Good example of this scientific leadership is the Tenderometer—invented by Canco scientists—to help growers measure the ripeness and tenderness of peas so they can be picked at their very peak of goodness. Back of the oval, too, are the constant efforts of Canco to help canners make their products better and better.

AMERICAN CAN COMPANY

New York • Chicago • San Francisco

Who put the Ac'cent in Mrs. America's Soup?

Almost everybody seems to be responsible, because over 95% of all soups, both canned and frozen, use monosodium glutamate. Ac'cent protects food flavor in heat-'n-eat foods, just as it does in fresh meats and vegetables. The flavor of your product builds and holds business for you. Isn't that precious flavor worth protecting with Ac'cent?

Let us show you how Ac'cent can improve flavor. Just drop us a line. We'll send you this important information, and a special Ac'cent file folder to keep it handy. No obligation. Ac'cent • International, 20 N. Wacker Dr., Chicago 6, Ill.

Ac'cent®

BRAND

Pure Monosodium Glutamate

(Continued from page 59)

Everett 49, Mass. The unit handles over 65 different types of food and chemical materials, from fluid to highly abrasive. An invitation is extended to use the laboratory facilities and research department of Manton-Gaulin for analyzing processing requirements.

◆ ◆ ◆

Twelve models of Nor-Lake Reach-In Refrigerators, including the new "window-door" models, are listed in a catalog sheet recently issued by Nor-Lake, Inc., Hudson, Wis.

◆ ◆ ◆

Felton's new 1956 flavor catalog presents this manufacturer's comprehensive range of flavoring materials in an easy-to-follow style, divided into sections according to their applications. Particular emphasis is given to the expanded line of true fruit and locked-in flavors. Address Felton Chemical Co., Inc., 599 Johnson Ave., Brooklyn 37, N. Y.

◆ ◆ ◆

It is estimated that employee absenteeism costs industry $10 billion annually. To help guide management and labor toward a possible alleviation of this problem, Occupational Health Institue, Inc., offers its current free Service Bulletin, "Absenteeism." The OHI address is 6 E. 39th St., New York 16, N. Y.

◆ ◆ ◆

The booklet, "Soap is Essential to Health, Welfare, and Morale," published by the Cleanliness Bureau of the Association of American Soap & Glycerine Producers, Inc., 295 Madison Ave., New York 17, N. Y., contains some 200 statements about the importance of soap-and-water cleanliness, made by leading health, medical, government, business, and other authorities. It is intended as a reference source useful in health programs, personnel training, plant management and maintenance, food handling, and in preparing educational manuals.

◆ ◆ ◆

The second edition of its General Catalog is offered by Automatic Temperature Control Co., Inc., 5200 Pulaski Ave., Philadelphia 44, Pa. Some of the products covered are differential transducer control and automation systems, a complete line of time control equipment, including electronic, equipment operator mechanisms, valves, counters, and electronic contractors. Write for Catalog D-31.

◆ ◆ ◆

"The Vital Story of Cereal Grain Products—Enriched with Vitamins and Iron for Better Nutrition," a 20-page illustrated brochure published by the Vitamin Division, Hoffmann-La Roche, Inc., Nutley 10, N. J., treats, in separate chapters, the value of enrichment to white flour, white bread, macaroni products, corn meal and grits, white rice, farina, and prepared breakfast cereals.

. . . *meeting hall and conference room*

The 1956 short course of the American Oil Chemists' Society, scheduled for Purdue University, July 16-20, will treat of unit processes in the fatty oil, soap, and detergent industries. At the Society's fall meeting, to be held September 24-26 at the Hotel Sherman, Chicago, announcement will be made of the winner of the Fatty Acid Producers' Award, given by the Fatty Acid Division of the Association of American Soap and Glycerine Producers, Inc., and administered by AOCS. Deadline for entries is August 1. AOCS headquarters is located at 35 E. Wacker Dr., Chicago 1, Ill.

◆ ◆ ◆

The Committee on Vacuum Techniques, Inc., invites presentation of papers at the Third Symposium on Vacuum Technology, to be held October 10-12 at the Hotel Sheraton, Chicago. Papers are desired particularly in the following catagories: fundamental developments in vacuum technology; methods and techniques for obtaining high vacuum; instrumentation and control of high vacuum equipment; vacuum distillation and evaporation; metallurgical and chemical applications; and vacuum technology as related to atomic energy and extra-terrestrial problems. Title or letter of intent should be sent to the program chairman, Dr. E. S. Perry, Distillation Products Industries, 755 Ridge Rd. W., Rochester 13, N. Y.

. . . *building up and branching out*

Realignment of existing chemical operations and establishment of a new company division was announced by Mr. Hugh S. Ferguson, executive vice president for the chemical group of W. R. Grace &

(Continued on page 64)

Gorton's®

protects end-product uniformity...

...with automatic viscosity control

In this compact WILEVCO System engineered by W. L. Cummings and Co., a Foxboro Dynalog Controller (center) maintains desired batter consistency and provides a continuous record of viscosity. Viscosity-sensing element is the Brookfield Viscometran (right).

To meet the high quality control standards at Gorton's of Gloucester all fish sticks must be extremely uniform in size, weight, and appearance when packaged. Hence the batter in which they are dipped, prior to breading and frying, must be of uniform consistency. This famous fish processor relies on a Foxboro Dynalog Controller working with a Brookfield Viscometran, to keep batter consistency uniform *automatically*.

In this compact control system, viscosity of the batter is sensed by the Viscometran and continuously recorded by the Dynalog Instrument. Also, sump level is sensed by an electrical probe. Both the batter viscosity and sump level are automatically maintained by interlocked electrical control which adds either water or dry mix (or both) to hold level and consistency within the desired limits.

This installation is typical of hundreds throughout the food industry in which Foxboro Instrumentation is assuring processors highest efficiency, quality, and economy. For details on control of your process, consult your Foxboro Field Engineer, or write **The Foxboro Company, 356 Norfolk St., Foxboro, Mass., U.S.A.**

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

FOXBORO
REG. U. S PAT. OFF.

INSTRUMENTS THAT IMPROVE PRODUCT QUALITY

SANITATION
starts with
IN-PLANT CHLORINATION

From start to finish of your processing operation, *Wallace & Tiernan In-Plant Chlorination* will keep your sanitation problems to a minimum by:

- Eliminating slime formation on equipment and in work areas
- Retarding bacteria growth
- Greatly reducing offensive odors

For information on how In-Plant Chlorination can help solve *your* sanitation problems, write today to our Foods Division.

WALLACE & TIERNAN
INCORPORATED
25 MAIN STREET BELLEVILLE 9, N. J.

I-46

(Continued from page 62)

Co., 3 Hanover Sq., New York 4, N. Y. The former Dewey and Almy Chemical Co., of which Mr. Ferguson was president prior to its merger with W. R. Grace & Co. and until his election to the Grace post, now is divided into 3 divisions of the parent company. The Dewey and Almy operations under the historic name will be headed by Mr. Geo. W. Blackwood as president and Mr. Wm. L. Taggart, Jr., as executive vice president. The CRYOVAC Company Division will have Mr. Bradley Dewey, Jr., as president. Dewey and Almy Overseas Company Division will be headed by President Henry L. Gilbert. The new division of W. R. Grace & Co., the Polymer Chemicals Division, will be headed by Mr. T. T. Miller as president and Mr. Elwyn E. Winne as vice president. A polyethylene plant for this division is under construction at Baton Rouge, La.

◆ ◆ ◆

Pennsylvania Salt Mfg. Company has announced expansion of chloro-caustic facilities at its Calvert City, Ky., works as part of its $55 million growth program. The new unit will increase chlorine production from 50 to 150 tons a day, with accompanying increase of rayon grade caustic soda production. It is anticipated there also will be an increase in caustic potash production. The unit will go into operation during 1957.

The new, multi-million dollar Morton Salt Company laboratory, designed especially for the conduct of research projects related to salt and its usage, now is in operation at Woodstock, Ill., a short distance northwest of Chicago. The 67-room structure, located on a 22-acre site, houses a hand-picked staff of top chemists and chemical engineers headed up by Dr. Robert L. Frank. The building was constructed so that it could easily be expanded by future construction if research operations make this necessary.

◆ ◆ ◆

Atlas Powder Co., Wilmington, Del., has established a new department to handle license, patent, and trademark matters for all divisions and departments of the company, is was announced by Mr. Ralph K. Gottshall, president. Mr. Kenneth E. Mulford has been named to direct the new department. In addition, he will continue to serve as assistant to Mr. Edward J. Goett, vice president in charge of Atlas' chemicals division. Mr. Roger R. Horton, of the Atlas legal staff, has been appointed assistant director of the new department.

◆ ◆ ◆

American Trading Co., with offices in Tokyo and Osaka, is the new Japanese sales representative for F. Ritter & Co., Los Angeles manufacturer of essential oils and aromatics. Shown above, celebrating the appointment in one of Tokyo's most fashionable restaurants, are officials of American Trading. From left: Mr. Akira Takasu, assistant; Mr. Hikojiro Majima, manager of the essential aromatics department; Mr. Edwin P. Seaves III, director; and Mr. G. T. Weed, manager, chemical commodity division. The gentlemen are eating Tempura, a tasty Japanese seafood dish.

◆ ◆ ◆

Chas. Pfizer & Co., Inc., officially opened its Northwestern Distribution Center in Portland, Ore., on April 18. All four of the firm's domestic divisions—Pfizer Laboratories, J. B. Roerig and Co., Chemical Sales, and Agricultural Sales—will use the distribution facilities of the Center, located at 3333 N. W. Industrial St. The new Center follows completion of others in Atlanta, San Francisco, and Dallas. A fifth is being constructed to replace older facilities in Chi-

(Continued on page 66)

PRIZE-WINNING BUTTERMAKERS PREFER DIAMOND CRYSTAL FLAKE BUTTER SALT!

MEMO
FROM WILLIAM FOSTER

Jim --

It looks like these Diamond Crystal people make a salt with just the right purity and grain size for every purpose.

Don't you think it would be a good idea to find out how Alberger Salt can help improve our operation?

Bill

Mr. Donald Hedding, of the Hillsboro Cooperative Creamery Co., Hillsboro, Wis., First Prize Winner for Sweet Cream Butter in the 1954 National Butter Scorings at the National Dairy Cattle Congress, Waterloo, Iowa. His butter won the same award in 1950. In both 1949 and 1950, Donald Hedding's sweet cream butter won First Prize in all classes at the Wis. State Fair.

...rystal Flake Butter Salt for over 10 years," says prize winner Donald Hedding, "because Diamond Crystal's 'soft flakes' consistently do the best job in buttermaking of any salt I've ever seen! I'm sold on the way it dissolves quickly and completely in butter... leaves no grittiness. Diamond Crystal Flake Butter Salt never requires extra-long working which can produce mottled, sticky butter. It has a pure salt flavor that never imparts a strong, brackish flavor to butter. I've seen what it can do," says champion Donald Hedding, "and that's why it's my choice!"

Prize-winning butter is the result of many factors—skill born of long experience, painstaking care, good equipment and quality ingredients.

Diamond Crystal Flake Butter Salt helps you make better butter because:

- **It's the only Butter Salt made by the exclusive Alberger Process of refining which produces unique, quick-dissolving flake crystals!**
- **It's pure—highest uniform purity assures true salt flavor!**
- **It's uniformly sized—precision screening produces flakes that are just the right size and solubility for good buttermaking!**
- **It's clean—the lowest insoluble content of any butter salt!**
- **It's low in heavy metals—less than 1.5 parts per million of pro-oxidants copper or iron!**

DIAMOND CRYSTAL FLAKE BUTTER SALT

America's Largest-Selling High-Grade Butter Salt!

For further information, write to: Dairy Dept., Diamond Crystal Salt Co., St. Clair, Michigan

(Continued from page 64)

cago. The company has plants in Brooklyn, N. Y., Groton, Conn., and Terre Haute, Ind.

◆ ◆ ◆

General Controls Company announces completion of a new building at 600 Bryant Street that will increase its San Francisco facilities by 120 percent. The firm maintains manufacturing plants in Glendale and Burbank, Calif.; Skokie, Ill.; Iron Mountain, Mich.; and Guelph, Canada. Forty-two branch offices extend over the U. S. and Canada; seven regional warehouses help carry the stock.

◆ ◆ ◆

Announcement of 5 new representatives of the Penn Industrial Instruments Division, Burgess-Manning Co., 4110 Haverford Ave., Philadelphia, Pa., has been announced by Mr. D. W. Day, vice president. The following firms will handle sales of control and measuring equipment for municipal sewage and industrial waste problems: E. R. Parkhurst Co., Los Angeles—Southern California and Arizona; A. J. Kroog Co., Atlanta—Alabama and North and South Carolina. Representatives handling the general line of control and flow instruments for industry are: M. S. Jacobs & Associates, Carnegie, Pa., and Buffalo, N. Y.—Western New York, Western Pennsylvania, and West Virginia; Williams Equipment Co., New Orleans—Louisiana and lower Mississippi; and T. I. Equipment Co., Cleveland—northern and eastern Ohio.

. . . *the human element*

Mr. C. G. Harrel has been appointed director of the new products idea department of Pillsbury Mills, Inc., Minneapolis, under the direction of Mr. G. R. Detlefsen. Mr. Harrel came to Pillsbury in 1932 as director of product control and bakery research. Subsequently, he served as director of the research laboratory and as associate director of research and product development before taking over the directorship of food research in 1952. **Dr. Howard E. Bauman,** a member of IFT, has been appointed head of the food research branch to fill the position formerly held by Mr. Harrel. Dr. Bauman came to Pillsbury in 1953 directly from the University of Wisconsin where he obtained his graduate degrees.

◆ ◆ ◆

Wood—Stange's seasoned veteran makes good!

In connection with the company's current expansion program, Mr. Wm. B. Durling, president of Wm. J. Stange Co., 342 N. Western Ave., Chicago, recently announced appointment of **Mr. C. A. Wood** to the newly created position of director of sales, and **Mr. F. K. Koepke** to that of sales manager. Mr. Wood, a member of IFT and active in the food processing industry since 1927, joined Stange in 1947. Mr. Koepke became associated with the firm in 1942. As sales manager he will continue to handle the company's advertising.

◆ ◆ ◆

Mr. Orville K. Schmied, a vice president of Cochran Foil Co., 1430 S. 13th St., Louisville 1, Ky., has been appointed director of research and development of products and processes. The company also announces appointment of **Mr. Merrill A. Grogel** as general manager of the Products Division, and **Mr. J. B. Gage** and **Mr. K. W. Foster** as district managers in Cleveland and Chicago, respectively.

◆ ◆ ◆

For Staley—vim, vigor, and Volle!

Mr. Henry Volle, advertising manager of the corn division of the A. E. Staley Mfg. Co., Decatur, Ill., has been promoted to assistant manager of the firm's grocery products department. Named to the position Mr. Volle leaves is **Mr. Gene Staley,** who has been advertising manager in the soybean division. **Mr. Paul Kirkpatrick,** also an assistant manager of the grocery products department, will continue in his position. He is largely concerned in general administration work with branch offices, salesmen, and brokers. Mr. Volle is being assigned primarily to sales promotion and new product development in his new job, which is a newly created post.

On May 18, the Staley Company opened its new Chicago office and warehouse at 4616 W. Augusta Blvd.

◆ ◆ ◆

American Meat Institute Foundation, 939 E. 57th St., Chicago 37, Ill., announces the availability of a

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

June 4-9	Ninth Annual Microbiological Institute, Purdue University, Lafayette, Indiana. Theme, "Know the Molds."
June 6-9	**Sixth Annual Convention of the Australian Sections of IFT, Ritz, Leura, N. S. W. Australia**
June 10-14	**Sixteenth Annual Meeting of the Institute of Food Technologists, Sheraton-Jefferson Hotel, St. Louis, Missouri**
June 18-22	International Congress on Food Distribution, Rome, Italy
June 18-29	Special Summer Program on Perspectives in Food Technology, Massachusetts Institute of Technology, Cambridge
June 20-22	The 52nd Annual Meeting of the National Macaroni Manufacturers, Wentworth-by-the-Sea, Portsmouth, New Hampshire
July 9-11	The Second Symposium on "Foreign Chemicals in Foods," Amsterdam, Holland
August 17-25	Tenth International Congress of Entomology, McGill University and the University of Montreal, Montreal, Canada
Sept. 10-17	The Perkin Centennial, Sponsored by the American Association of Textile Chemists and Colorists, Commemorating the Discovery of Aniline Dyes, Waldorf-Astoria Hotel, New York
Sept. 16-21	One hundred and thirtieth National Meeting of the American Chemical Society, Atlantic City, New Jersey

list of graduate students in the fields of bacteriology and biochemistry. Many of these students are interested in considering positions with industry during 1956, 1957, or 1958. For information, contact Dr. C. F. Niven, Jr. (bacteriology) or Dr. B. S. Schweigert (biochemistry) of the Foundation staff.

◆ ◆ ◆

for a company man
Pascal—recognition

Election of **Mr. Donald D. Pascal** as executive vice president, succeeding the late A. A. Halden, and **Mr. Wm. C. Buffing** as treasurer of National Starch Products, Inc., 270 Madison Ave, New York, N. Y., was announced by Mr. Grank Greenwall, president. Mr. Pascal, 48, has been with National Starch Products throughout his business career, having joined the organization in 1929. Mr. Buffing, 38, was formerly company controller.

◆ ◆ ◆

Mr. Wm. J. Aichele and **Mr. Howard J. Newby** have been promoted to section heads in product and process development and engineering and commercial development, respectively, at the General Foods Central Laboratories, Hoboken, N. J. **Mr. Bert Borders,** formerly manager of the customer service department of Basic Vegetable Products, Inc., has been appointed a project leader at the Central Laboratories. All of the above are members of IFT.

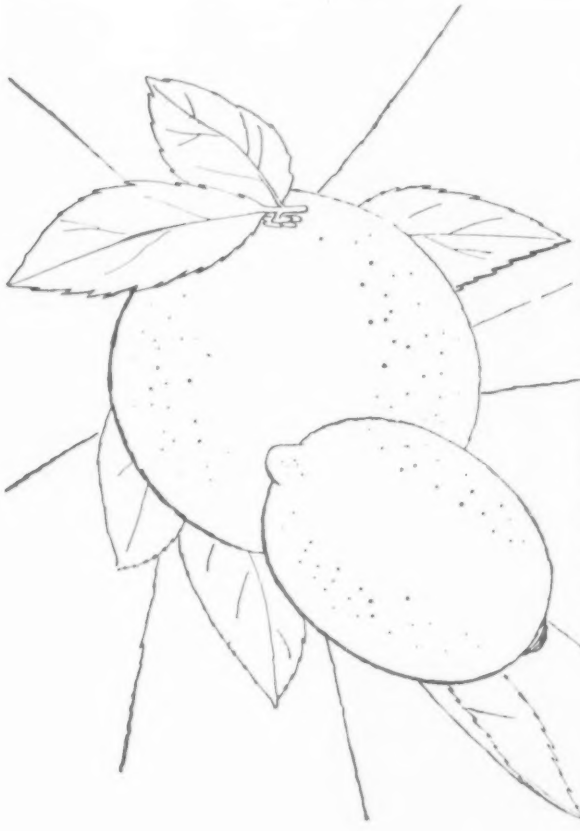
◆ ◆ ◆

Griffith—a special
gift for Special Gifts!

A resident and active in civic affairs of Millburn Township, Essex County, N. J., for 15 years—**Mr. F. W. Griffith** accepted appointment as chairman of the Special Gifts Committee in his community's Cancer Fund Drive. As vice president and secretary of The Griffith Laboratories, Inc., IFT member Griffith is in charge of operations at the company's Newark plant, and directs Canadian, Mexican, Brazilian, and all export activities.

◆ ◆ ◆

Appointment of **Dr. Myron Brin** to the position of chief biologist has been announced by Food Research Laboratories, Inc., 48-14 Thirty-third St., Long Island City 1, N. Y. Dr. Brin formerly served as research associate at Thorndike Laboratory, Boston City Hospital, instructed in biological chemistry at Harvard Medical School and Harvard College and was affiliated with the Cancer Research Institute, New England Deaconess Hospital in Boston. In his new post, he



ACCESSORY NUTRIENT FACTORS

For the luxuriant growth of all lactic acid bacteria yeasts and molds assured by the use of

EXCHANGE BRAND ORANGE SERUM AGAR #77
(Dehydrated) a Complete Culture Medium

FORMULA
Ingredients—when rehydrated on basis of 45 grams per liter of medium.

Orange juice serum solids	12.6g*
Agar (dry basis)	15g
Peptone	10g
Yeast hydrolysate	3g
Reducing sugars, total	8g
Sucrose, total	6g
Cysteine hydrochloride	0.031g

Buffered with 0.2 to 0.6g K_2HPO_4 to provide pH 5.5 ±0.05 after sterilization.
**Equivalent to 100 ml 12° Brix orange juice serum.*

STANDARDIZED for uniformity and stability.

POTENTIAL APPLICATION—Orange Serum Agar as an all-purpose medium has a wide application to the bacteriologist and microbiologist in the milk, fruit, pickling, food, bottling and fermentation industries.

Available in 1 lb. bottles through your laboratory supply house.

Sunkist Growers
PRODUCTS DEPARTMENT

Exchange®

PHARMACEUTICAL SALES · ONTARIO, CALIFORNIA

SeaKem "Colloids Out of the Sea"*
unique...
both in their reactivity with proteins and their ability to work well "in combination" with other colloidal materials
*Over 20 distinct types of SeaKem Stabilizers are available . . . each one a highly refined derivative of Irish Moss and standardized for a particular gelling, thickening, suspending or other function.
EXTRACTS
Ask to be put on our mailing list to receive SeaKem EXTRACTS — the exciting house organ that "tells all" about SeaKem "Colloids Out of the Sea"
Any special application problems? Write today!
Seaplant CHEMICAL CORPORATION
63 David Street, New Bedford, Mass.

succeeds **Miss Mona Oser,** who has been named assistant to the director.

◆ ◆ ◆

Mr. Lawrence S. Spiegel, candidate for the doctorate degree in food technology at Massachusetts Institute of Technology, has been announced as winner of the first Samuel Cate Prescott graduate-student fellowship for research on refrigeration of food by The Refrigeration Research Foundation, 200 Midland Bldg., Colorado Springs, Colo. The fellowship, which provides $2,500 for one year, is named in honor of Dr. Samuel Cate Prescott, dean of science emeritus at MIT, who is chairman of the Board of Governors of The Refrigeration Research Foundation. It is designed to encourage young men and women who wish to do research in the fields of refrigeration and refrigerated warehousing.

◆ ◆ ◆

Mr. C. T. Fuqua, Jr., president of Anderson, Clayton & Co., Foods Division, has announced appointment of **Mr. Wm. A. Jacob, Jr.,** as vice president, Foods Division, in charge of manufacturing and research. Mr. Jacob, formerly assistant general director of refineries for the company in Houston, Texas, will make his headquarters at the Foods Division general offices in Dallas, Texas.

◆ ◆ ◆

Blaw-Knox., Chemicals Plants Division, 300 Sixth Ave., Pittsburgh, Pa., has announced promotion of **Mr. Ralph Berger** to manager of special process sales. He will direct sales and project engineering for all fats and oil processes from the company's midwest headquarters in Chicago.

◆ ◆ ◆

Dr. Sam R. Hoover, an assistant chief of the USDA's Eastern Utilization Research Branch in Wyndmoor, Pa., received the Borden Award in the Chemistry of Milk (April 9) in Dallas, Texas, at the 129th National Meeting of the ACS. In presenting the award, consisting of a gold medal and $1,000, ACS President J. C. Warner made special mention of Dr. Hoover's discovery of the specific groups of the milk protein casein that are responsible for its absorption of water. Dr. Warner pointed out that this research was of extreme importance in development of improved dried milk products. Dr. Hoover, in accepting the award, paid tribute to the efforts of his research team—in particular, **Dr. Edward F. Mellon** and **Mr. Alfred H. Korn** of the EURB.

Hoover—his team is all right!

◆ ◆ ◆

The Best Foods, Inc., 1 E. 43rd St., New York 17, N. Y., has announced election of **Mr. Jerome M. Rosefield** to its Board of Directors. Mr. Rosefield is vice president and general manager of the firm's Skippy Peanut Butter Division.

◆ ◆ ◆

At recent ceremonies held at the Quartermaster Research and Development Command headquarters in Natick, Mass., two Quartermaster Food and Container Institute (Chicago) scientists were honored for outstanding achievement in 1955. In the top photo, Specialist Third Class George W. Kurtz receives the Research Directors' Award of the Quartermaster Research and Development Command for his work in developing a successful process for removing oxygen from hermetically sealed containers through use of an in-package "oxygen scavenger."

In the lower photo, Dr. Doris H. Calloway receives a Technical Directors' Award Honorable Mention in recognition of her research on the nutritive properties of processed, stored rations. Making the presentation in each case is Brig. Gen. Chas. G. Calloway, commanding general, Hq., Quartermaster Research and Development Command. Looking on at left and right, respectively, are Dr. A. Stuart Hunter, scientific director, Hq., Quartermaster Research and Development Command, and Dr. Robert G. Tischer, director, Food Laboratories, Quartermaster Food and Container Institute.

Mr. Harrison C. Givens, Jr., former manager of the Mfg. Dept., Textile Division, Celanese Corporation of America, 180 Madison Ave., New York 16, N. Y., has been made vice president-Operations of Celanese International Corp. In his new executive capacity, Mr. Givens will be responsible for providing continuing liaison between Canadian Chemical & Cellulose Co., Ltd., the Celanese affiliate in Canada, and Celanese Corporation of America. His new headquarters will be in New York City.

Celanese's Givens —an eye on P. E. I. and points west

The firm also announced that construction is under way on a major expansion of its Bishop, Texas, chemical plant designed to increase by 25% that plant's production of formaldehyde, methanol, acetaldehyde, and certain other organic chemicals.

Appointment of **Mr. W. F. Twombly,** vice president of Witco Chemical Co., 122 E. 42nd St., New York 17, N. Y., as a consultant on organic chemicals in the Chemical and Rubber Division of the Business and Defense Services Administration, U. S. Department of Commerce, was announced recently. During Mr. Twombly's temporary service in Washington, his duties at Witco will be assumed by **Mr. Wm. C. Walker,** assistant director of advertising and public relations.

RECENTLY ELECTED MEMBERS OF IFT

(Continued from page 36 preceding technical papers)

Horton A. Dufty
Shoreland Freezers, Inc.
Salisbury, Md.

Robert Elias
Felton Chemical Co.
599 Johnson Ave.
Brooklyn 37, N. Y.

Roderick K. Eskew
Eastern Utiliza. Research Br.
600 E. Mermaid Lane
Philadelphia 18, Pa.

J. A. Glerum
Blikemballagefabriek
Thomassen & Drijver, N. V.
Postbus No. 103
Deventer, Holland

Rafael R. Gutierrez
P. O. Box 23537
Mexico, D. F., Mexico

Patricia Hayes
21 Brynwood Road
Yonkers, N. Y.

Gilbert L. Henning
Golden Citrus Juices, Inc.
P. O. Box 552
Fullerton, Calif.

Dr. Eric J. Hewitt
300 Broadway
Dobbs Ferry, N. Y.

Dr. Robert J. Hlavacek
Swift & Co., Research Lab.
U. S. Yards
Chicago 9, Ill.

Gordon K. Jensen
Gentry Div., Consol. Foods Corp.
Box 2076 Terminal Annex
Los Angeles 54, Calif.

Calvin P. Jingst
228 A. Dogwood
Park Forest, Ill.

Edward W. Jones
Meinrath Brokerage Co.
20 W. 9th St., Rm. 500
Kansas City 5, Mo.

Jerome G. Kaufman
Felton Chemical Co.
599 Johnson Ave.
Brooklyn, N. Y.

Barbara J. Kenrick
General Motors Corp. Frig. Div.
300 Taylor Street
Dayton 1, Ohio

Philip G. Kiely
Arthur D. Little, Inc.
292 Main St.
Cambridge 42, Mass.

Jerome Leonard
College Inn Food Products Corp.
4301 S. Ashland Ave.
Chicago 9, Ill.

Dr. Donald A. M. Mackay
367 Parkview Ave.
Tuckahoe, N. Y.

Richard H. Maurer
The Cleveland Fruit Juice Co.
3506 Vega Ave.
Cleveland 13, Ohio

Dr. Ahmad M. Moustafa
714 Oakwood Ave.
Oconomowoc, Wis.

Margaret B. New
1224 Strahley Place
Pittsburgh 20, Pa.

Thomas H. O'Connor
Golden Citrus Juices, Inc.
P. O. Box 552
Fullerton, Calif.

William H. Orth
1465 Walnut St.
San Carlos, Calif.

Gerard E. H. Pairaudeau
Metal Box Co. Ltd.
Cambridge House
London W-1, England

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